Future@Labs.Prosperity
PROSPERITY GAME©

Players' Handbook

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Sponsored by

LLNL Industry Advisory Board
LANL Industry Advisory Board
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Lockheed Martin Energy and Environment Sector
University of California
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
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Prosperity Games

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INTRODUCTION

Future of the DOE National Laboratories

The future of the DOE national laboratories is a major topic of discussion in Washington, as are federal and industrial investments in research and development. The end of the Cold War created expectations of a "peace dividend." The new Republican majority in the 104th Congress committed itself to reduce the deficit, cut or eliminate many federal programs, and require that government expenditures be justified by their benefits to the nation. Some have forecast that federal support for research will be reduced by 30% over the next five years.

The primary mission of the original national laboratories was the creation and maintenance of the nuclear deterrence portion of the national defense system. Over the years, additional missions have been created in the areas of civilian nuclear power, energy R&D, and environmental research and waste management. A huge national investment has been made in laboratories facilities, infrastructure and the creation of a pool of enormously talented scientists and engineers.

With the diminution of the threat of global war and the reduction of federal spending on science and technology, the US "Technology Delivery System" is being reevaluated in terms of national needs, missions, funding resources (federal, industry, foreign) and R&D performers (national laboratories, universities, industry, foreign countries).

A year ago, the Galvin Commission[1] concluded that "energy" in its broadest definition should serve as the mission for the labs. "The laboratories' research role is a part of an essential, fundamental cornerstone for continuing leadership by the United States…. We note that many of the least exploited investigative paths involve the need for extraordinarily sophisticated multidisciplinary teams using sophisticated instruments and tools. It is that role for which the national laboratories are uniquely qualified. It is the case for – the justification of – the existence of the DOE laboratories…. The Task Force does believe that the national laboratories serve a distinctive role in conducting long-term, often high-risk R&D, frequently through the utilization of capital-intensive facilities which are beyond the financial reach of industry and academia, and generally through the application of multidisciplinary teams of scientists and engineers."

Although the Task Force supported innovative applications of the labs' technical competencies (e.g., high performance computation, advanced materials, systems engineering) to new problem areas, they suggested that these applications would not be likely to evolve into new missions *per se*.

More recently, a National Academies of Sciences and Engineering committee chaired by Frank Press[2] recommended closing some national labs and directing more research funds away from the labs and into universities.

In any period of resource contraction, there is a tendency for in-fighting and competition for the shrinking pie. However, it is also possible that the interests of all can be better met by partnerships, synergistic approaches, and the reduction of redundancy. Metrics on the return on private and public investments are essential.

Science and technology may play a large role in the '96 elections. On February 15, Vice President Gore said "… we have a choice of two paths. One path retreats from understanding, flinches in the face of challenges and disdains learning…. But there's another path… on which government continues funding basic science and applied technology. It's a path that keeps the virtuous circle of progress and prosperity alive and functioning…. It's a path that applies what we've learned from science to the rest of our lives."

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[1] Department of Energy, Task Force on Alternative Futures for the Department of Energy National Laboratories, February 1995, http://www.bnl.gov/TID/GALVIN/gv1.html.

[2] Allocating Federal Funds for Science and Technology, Committee on Criteria for Federal Support of Research and Development, National Academy Press, Washington, DC 1995, http://www.nap.edu/nap/online/fedfunds/part1/determining.html

This Prosperity Game

The Industry Advisory Boards of the national laboratories, in collaboration with the laboratories, Lockheed Martin Corporation, and the University of California, are sponsoring this Prosperity Game to explore the roles of industry, government, universities, and laboratories in the rapidly changing research environment.

This simulation will provide participants with an understanding of some of the threats and opportunities associated with the current US technology delivery system. It will be an invaluable learning experience that can create exciting *alternative* futures as well as explore the current *real* world.

OBJECTIVES OF THIS GAME

This Prosperity Game© is designed to accomplish the following specific and general objectives:

SPECIFIC:

- Explore ways to optimize the role of the multidisciplinary labs in serving national missions and needs.
- Explore ways to increase collaboration and partnerships among government, laboratories, universities, and industry.
- Create a network of partnership champions to promote findings and policy options.

GENERAL:

- Develop partnerships, teamwork, and a spirit of cooperation among industry, government, laboratory and university stakeholders.
- Increase awareness of the needs, desires and motivations of the different stakeholders.
- Bring conflict into the open and manage it productively.

Freedom rings where opinions clash.
- Adlai E. Stevenson

- Explore long-term strategies and policies.
- Provide input for possible future legislation.
- Stimulate thinking.
- Provide a major learning experience.

The specific objectives are met by the players and teams acting separately and in concert with others to explore the future and their own challenges. General objectives are met through the simulation process itself.

GAME CONCEPT

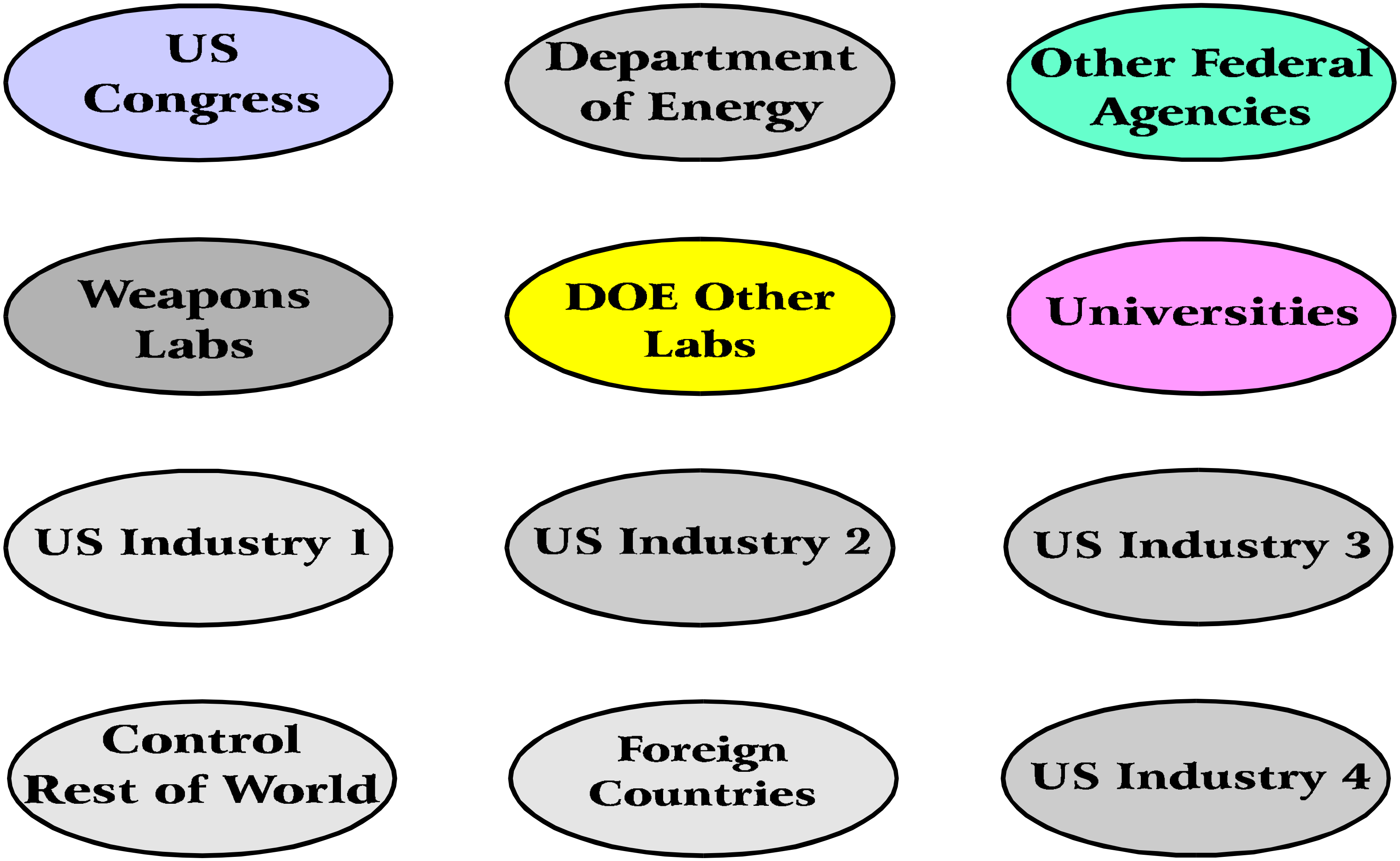
Teams:

The game incorporates the twelve basic teams shown in Figure 1. The *US government* is simulated by three teams representing the **US Congress,** the **Department of Energy,** and **Other Federal Agencies** (e.g., DOD, DOC, DOT, DOA, HHS, NASA, EPA, NSF, FAA, etc.). *US industry* is simulated by **four Industry teams** representing four different technology focus areas: information technology and advanced manufacturing; energy and environment; life sciences and advanced materials; and national security and criminal justice. National security, broadly defined, (see GLOSSARY) may also be of major interest to other teams. Other technology areas like sensors, instrumentation, micro-electronics, photonics, robotics, etc., should be pursued by any team with an interest in those technologies. Foreign governments and businesses are represented on the **Foreign Countries** team. The research establishments are represented by a **University** team and by two lab teams, **the DOE Weapons Labs** and the **DOE Energy, Environment and Other Labs**; of course, R&D can also be performed by industry. The **Control Team** conducts the game, resolves all disputes, and plays all other roles and functions required in the game including news media, publications, polling, computing, adjudicating, and if needed, finance, labor, voters, special interest groups, etc.

Players:

Every Prosperity Game is unique because the outcomes depend on the players. Players have been selected to faithfully represent their real-life roles. Their creativity and commitment to the simulation determine the success of the game. A list of the players and their team assignments is given in Appendix A.

Figure 1. This Prosperity Game will explore relationships among many entities.



Game Description and Scenario:

The primary game objective is to explore the roles of the labs in serving national missions and needs. This exploration requires highly skilled players with a strong knowledge of the existing R&D system, and the confidence to make decisions, observe their consequences, and alter their decisions accordingly.

The game schedule is shown on the back cover. The play runs from May, 1996 to the end of 2005, a compression of ten years into two days. This time compression of 2000:1 (1 game minute ≈ 1.5 days) means that many aspects and issues will be treated very approximately.

The central theme of the game, as in real life, is the relationship among all the stakeholders in the competition for scarce public and private resources. The people are concerned about the percentage of national income that is taken by the government, and the allocation of that money to competing government needs, especially between current consumption and future investment. Industry is also concerned about the allocation of resources to ongoing company operations versus future investments. All stakeholders would like to have metrics to evaluate the success or failure of previous decisions and to help guide future decisions.

Players are assigned to one of the stakeholder teams. They are expected to play their assigned roles faithfully by protecting the interests of their constituents. Challenges have been defined for each team. The players will review and modify those challenges and develop others. They will then develop strategies to accomplish their objectives and meet their challenges over the course of the game.

The game has few rules. The primary "move" in the game is a written agreement or contract, which represents a step along the path leading to the accomplishment of the team's objectives. The agreements should be robust, penetrating, and carefully crafted. These agreements are negotiated among two or more teams and must represent an exchange of value for value. The quality of the agreements is more important than their quantity.

Figure 2 shows the form to be used for documenting agreements. No agreement is official until signed by all parties and the Control Team. If the agreements involve uncertain future outcomes (such as the result of a new research investment), these will be determined probabilistically by the Control team for the final execution. The agreements must be accompanied by the amount of money being invested by the partners. Teams will be allocated money during the game to use to accomplish their objectives. Allocations will approximately model the real world. An important test for any "move" (action, agreement, contract, partnership) is its **reality**.

Players have two ways in which they can alter the future. One is the conventional approach discussed above that involves negotiations, contracts, and investments among the stakeholders in a realistic process that evolves within the game. These are the game "moves" that are recorded on the agreement forms. The second way to change the future is through Toolkit options (see p. 16). These are special technologies and policies that are provided to stimulate creativity in the game. The players can invest in the given options or create their own. Special allocations of Toolkit money or "credits" will be assigned; these credits can only be used for Toolkit investments. All Toolkit investments must be completed prior to the end of Session 2. Credits not spent cannot be used in the remainder of the game.

Three forms of assessment will occur during the game. The teams will assess themselves; they will be assessed by all the other teams; and they will be assessed by the Prosperity Games staff. Winners are those teams whose actions and decisions have most benefited the future of the nation and the teams' constituencies.

Figure 2. PROSPERITY GAMES AGREEMENT FORM

TERMS AND CONDITIONS: ____

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EXPECTED RETURN ON INVESTMENT AND JUSTIFICATION: ______________________

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Facilitator Review: ______________________

50% Probability Cost: $__________ ________________ Control Team ____________ Date/Time

APPROVALS AND FUND TRANSFERS

Team	Amount	Signature	Team	Amount	Signature
US Congress	$ ________	________________	Other Fed. Agncy	$ ________	________________
US Industry #1	$ ________	________________	Universities	$ ________	________________
US Industry #2	$ ________	________________	Weapons Labs	$ ________	________________
US Industry #3	$ ________	________________	Other Labs	$ ________	________________
US Industry #4	$ ________	________________	Foreign Team	$ ________	________________
DOE	$ ________	________________			

Investment was: ❒ Successful ❒ Unsuccessful

Approval by: ______________________________ Control Team ________ Date ____ Time

PLAYING THE GAME

The Prosperity Game includes six sessions or distinct time periods. The simulation explores empathic and learning experiences, collaborative and competitive interactions, experimentation, decision making, and innovation. The game and life experiences of the players are collected, discussed, prioritized, and documented in a final report. A final debriefing allows the teams to share their experiences with the entire group.

All teams are provided with a list of near-term and long-term challenges that can be modified or supplemented by the teams (see TEAM DESCRIPTIONS, CHALLENGES AND OPPORTUNITIES, p. 10). This information, coupled with the experience and expertise of the players, launches them into the real-world simulation of the game. The game is "won" by successfully meeting the prescribed challenges and accomplishing the long-term objectives of the teams and individual players. Circumventing the game is not winning. Players should seek to accomplish their goals following the most realistic alternatives available within the constraints of the simulation.

This experiential process develops the relationships and provides the inputs and innovative thinking that will be used for follow-on activities and planning.

Teams play their roles, and negotiate and interact with each other. They develop research plans; get sponsors and funding; invest in new technologies, implement new policies, get products patented, licensed and manufactured for use in subsequent years. All uncertain future results (e.g., successful research, successful development and testing, etc.) are determined probabilistically after the Control team has assigned a mean investment and mean time. A representative from a negotiating party must bring each agreement and the required money to Control for acceptance, probabilistic determinations, and confirmation. In the context of the game, all specified long-duration events (such as building new facilities for research or manufacturing) can be assumed to have already been accomplished in the event of a successful outcome.

Session 1: 1996-1997: This session focuses on strategic planning and organizing your team to best deal with the coming events. Decide on ground rules for making decisions, who will play what roles on the team, assignment of responsibilities, processes for accountability and correcting errors. Resolve outstanding questions about the game. Review your current state and where you would like to be in 10 - 20 years. Discuss the challenges provided in this Handbook (p. 10) and add others of your choosing; prioritize the list. Review the detailed descriptions of your team and other teams, and know the deadlines and deliverables. Begin to consider your technology and policy Toolkit investments. Negotiate with other teams. No money is disbursed in Sessions 1 or 2.

Session 2: 1997: Teams focus on the list of Toolkit technologies and policies, and determine how to invest their limited resources. Most Toolkit options will require partnering to yield higher probabilities of success. Toolkit investments must be submitted by the end of Session 2.

Teams are responsible only for their own Toolkit investments. However, they are encouraged to discuss pooling their Toolkit resources with other teams to increase the likelihood of success. Those discussions can be informal or formalized by an agreement between two or more teams. However, the Control team will only acknowledge each team's individual Toolkit submission.

After the Toolkit option investment period ends, teams must use realistic processes for developing and marketing new technologies. No Toolkit credits carry over to this process - all teams start from scratch. They may begin development of Toolkit options that previously failed, or create their own technologies and policies. (see TOOLKIT OPTIONS, p. 16).

Session 3: 1998-1999: Successful Toolkit options will be announced and implemented into the game. Money is distributed to all the teams according to a very approximate estimate of actual R&D spending and the relative influence of the different stakeholder groups. The allocations follow from our projections of the distribution of funds through the "food chain." Table 1 shows the baseline allocations to the teams for Sessions 3-5. Total funding is assumed to decrease by about 1.5-2% per year over the simulation. The money in the game represents national R&D expenditures only. Operating expenses are outside the focus of the game and should not be considered.

Table 1 was based on historical and projected allocations, with modifications to suit the format of this simulation (see Appendix B-2).

All the funding should be treated as discretionary and available for investments in the game.

The game design could have tracked the full process of taxation and distribution. However, because of time constraints and the possibility that one team's delay could completely stall the game, the preallocation method was selected. All teams are still expected to play their real roles and make any changes in the system appropriate to their roles and power. Hence, for example, the DOE could increase or decrease the discretionary funding to the labs; such changes would be implemented in the game in the following session. Similarly, Congress could increase or decrease the tax rate on industry, and this also would be implemented in the following session. Federal R&D funds could be increased or decreased in the game as a result of Congressional action with the approval of the President (Control team). However, such actions would entail real world consequences such as reductions in Medicare or increases in the deficit. The section on MONEY (p. 24) discusses the allocation formulas used to create Table 1, and illustrates how interrelated all the teams are.

Table 1. TEAM ALLOCATIONS AFTER FUNDING SHIFTS ($M)

Team	Session 3 1998-1999	Session 4 2000-2001	Session 5 2002-2003
US Congress	35	34	32
US Industry 1 (IT/Mfg.)	455	435	419
US Industry 2 (E/E)	156	150	144
US Industry 3 (LS/Mat.)	156	150	144
US Industry 4 (NS/CJ)	156	150	144
Department of Energy	16	17	15
Other Federal Agencies	128	125	119
DOE Weapons Labs	76	72	70
DOE Other Labs	76	72	70
Universities	247	238	231
Foreign Countries	160	160	160
Totals =	**1661**	**1603**	**1548**

Foreign funds in this game represent investments by foreign-owned companies in US R&D. US R&D investments abroad are not considered here.

The data and sources used to generate these funding and expenditure values are discussed in Appendix B-2.

Session 3 also creates the basic kernel (pattern for game play) for Sessions 4 and 5.

Figure 3 illustrates some (not all) of the possible interactions that could occur during Sessions 3 - 5. The background of the figure shows the R&D areas that the labs are currently pursuing.

Session 4: 2000-2001: Session 3 activities continue. Policy changes will also be incorporated into the game. Champions of particular technologies and policies should pursue the agreements necessary to bring their ideas to fruition.

At the end of Session 4, the President will convene a Summit Meeting to discuss the future of R&D in the U.S. Each team will elect a representative to the summit, which will be conducted as a plenary session.

Session 5: 2002-2003: Repeat Session 4 updated two more years. Active play ceases at the end of this session.

Session 6: 2004-2005: This session is for digesting the results of the game, and the progress each team has made in meeting its challenges and accomplishing its objectives. Follow-on activities will be proposed and discussed.

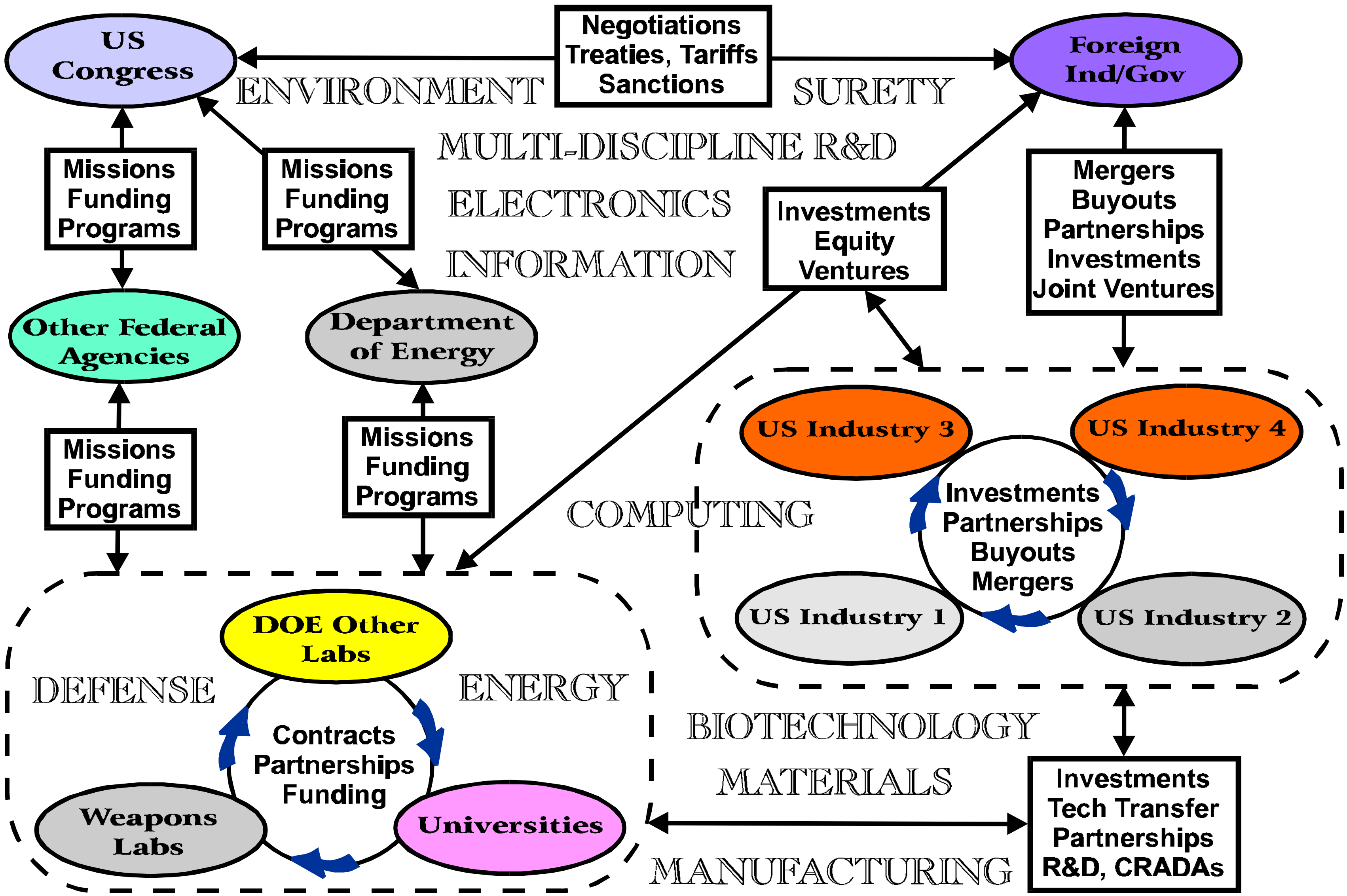
Outbriefings: Players prepare a final briefing. Each team selects a spokesperson. Topics should cover: Team issues and objectives; Interfaces with others (collaborative, competitive, other); What was learned; and Conclusions. Each team will be allowed no more than 5 minutes for the presentation.

Wrap up and final polling: Players answer questions and fill out evaluation forms.

Over the course of the game, six metrics will be tracked and updated by the Control team. These metrics are an attempt to estimate the impact of the players' moves on the future. The metrics are discussed in Appendix D.

Some unexpected events might occur during the game. These events may have a major or minor impact on the teams' deliberations, depending on the players' estimation of their importance.

Figure 3. Some Possible Team Interactions



TEAM DESCRIPTIONS, CHALLENGES AND OPPORTUNITIES

US Congress:

You represent members of the Senate and House of Representatives committees and subcommittees. These have been difficult times for Congress. The public has a low perception of congressional integrity and competence. The President and Congress often find themselves at loggerheads. The national debt is growing enormously, despite recent reductions in the annual deficit. Public confidence is very low. Some government entitlement programs have been projected to go bankrupt in the near future; e.g., Medicare in 2002 and Social Security in 2031. Nevertheless, you wield enormous power for change for the better or for the worse.

You are interested in exploring new ways in which the laboratories could function more effectively and more readily sustain themselves financially. The Senate is currently investigating all FFRDCs (DOE, DOD, NASA, EPA, etc.) to reduce costs and to better address national problems. You also have concerns about the trend for certain laboratories to engage in technology transfer activities, the possibilities of "corporate welfare," and potential competition with industry. You seek to direct the scientific and engineering resources of the federal laboratories toward the economic, environmental, defense, scientific, and energy needs of the United States in a more effective and efficient manner. You are especially concerned about the ability of the US to compete globally, and the role played by science and technology in this international competition.

Revenues for the future are fixed; however, if savings are realized, they can be applied to other governmental programs or to reducing the national debt. You need to develop a list of requirements, assign priorities, and allocate future tax income. Creative solutions are encouraged. You should consider technology priorities, quality of life issues, time lines, and metrics to judge your progress. However, given the differing viewpoints among the voters, you must make a strong case for your proposals in order to be reelected.

Challenges:

1. Outline your objectives for national R&D and the appropriate role of the federal labs; prioritize policies and technologies that will help you accomplish these objectives.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Ascertain the appropriateness or inappropriateness of the existing structure of the federal laboratories with respect to being located within DOE, and with respect to contracting for the laboratories' management with industrial corporations and universities (Government Owned, Contractor Operated - GOCO).
4. Decide whether or not a separate agency should be formed in which all or some R&D government organizations should be placed (with emphasis on the federal laboratories).
5. Determine if the federal laboratories should perform research outside DOE's traditionally mandated areas of responsibility, which are national security, energy, and environmental remediation, and if so, in what areas.
6. Determine whether the federal laboratories should be restructured, consolidated and/or managed as a system, and if so, how?
7. Propose new legislation that would mitigate your concern about the functioning of the federal laboratories, including any concerns relative to the lack of coordination/management among programs within the laboratories.

8. Determine the allocation of revenues to the various stakeholders and programs. Note that the R&D allocation may be increased, but only by taking funds from other existing programs such as Social Security or Medicare, or by increasing corporate taxes or increasing the deficit. See Appendix B-2 for more data.
9. Develop and pass new legislation dealing with R&D, the introduction of new technologies, and the role of science and technology in international economic competition.
10. Discuss and debate values and the appropriate role of government. Seek stakeholder inputs. Apply these values in proposed legislation.
11. Consider reelection issues.
12. Develop an appropriate set of metrics to measure the cost of government programs, their efficacy, and the return on taxpayer investments.

Department of Energy:

You represent the Department of Energy with a focus on federal laboratories; their management, mission adequacy, and effectiveness in meeting the requirements placed upon them.

Your mission is to contribute to the welfare of the nation by providing the technical information and scientific and educational foundation for technology, policy, and institutional leadership necessary to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense.

You are aware of concerns as to whether or not the current structure of the laboratories is the most effective. Excessive oversight and micromanagement are criticisms directed at DOE relative to management of its laboratories. Greater integration among applied energy programs has been cited as needed within the laboratories. Some have questioned the appropriateness of the laboratories being under the jurisdiction of DOE.

Environmental waste cleanup is a major DOE assignment. GAO estimated a cost of $1 trillion dollars to clean up DOE's waste sites. Total cleanup of waste sites in the US is estimated at $1.7 trillion dollars. Some experts state that new environmental technologies are required to lower costs and increase efficiency.

However, many people question not only the validity of your mission, but whether the department should continue to exist as it is currently structured.

Challenges:

1. Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Study the advantages and disadvantages of the transfer of the laboratories to another agency.
4. Consider a conceptual design for a new agency that would include the laboratories and other government R&D entities and provide a list of reasons stating why this would or would not be appropriate.
5. Generate a list of pros and cons for contracting the laboratories' management to private industry corporations.
6. Develop a strategic position about the environmental cleanup requirements for which DOE is legally responsible.
7. Design a synergistic strategy which will simultaneously address DOE's responsibility in the areas of nuclear weapons (stockpile security and reliability), national energy sources, environmental cleanup, and ecological sustainability.

8. Determine DOE's desired role in developing science and technology for increasing the US's international competitiveness.
9. Interact with other teams with respect to your findings, suggestions, and proposals.
10. Use your influence to change laws and regulatory practices.
11. Lobby Congress for the resources you feel you need, and allocate those funds to laboratories and other R&D organizations.

Other Federal Agencies:

The DOD is by far the major contributor to Federal R&D (~52%). To serve your mission of defending the country, you need to be at the forefront of new technology. You support research at your labs, the DOE labs, universities and industry. Your goal is to maintain defense superiority through technological improvements, and to get the best new technology at the lowest cost. Since your capabilities are provided by industry, it is important to work with industry and encourage dual use. You need to balance the value provided by the labs in advanced concepts with that provided by industry.

Additional significant research is funded by the National Institutes of Health (16%), the National Science Foundation (4%), NASA (12%), EPA, the Nuclear Regulatory Commission, and the Departments of Commerce, Agriculture, Transportation, and other federal agencies.

Challenges:

1. Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Determine priorities for the new technologies that would enable you to better accomplish your missions.
4. Determine ways and means to acquire these new technologies.
5. Assess the reliability of the nuclear stockpile, and DOE's commitment and capability to maintain the necessary readiness.
6. Determine the most effective way to use the combined strengths of universities, industry and federal laboratories.
7. Assess the GOCO (Government Owned, Contractor Operated) federal laboratories' management system relative to your interests in the federal laboratories, determine appropriate changes, and pursue these changes.
8. Interact with other teams with respect to your findings, suggestions, and proposals.
9. Use your influence to change laws and regulatory practices.
10. Lobby Congress for the resources you feel you need, and allocate those funds to laboratories and other R&D organizations.

US Industries/Companies:

You represent corporate America. You are interested in technical development which will result in enhancing your position in the marketplace; you are willing to enter into collaborative agreements with appropriate organizations for the research, development, and licensing of technologies which you believe your company can commercialize. You are concerned about specific "gray area" directives which govern the laboratories' ability to enter into such collaborative and joint venture agreements. You would like to simplify and expedite the CRADA process. You are also concerned about competition from the laboratories, and issues concerning ownership of intellectual property.

Your team is focusing on certain technology areas. However, you may partner with other teams to pursue common technologies or specific policies which you favor.

An industry team may form consortia among its own players or other industry teams, or form two or more conglomerates or sectors; however, it cannot represent a single company.

Challenges:

1. Develop a strategic plan or roadmaps for your industries that outline your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Learn about the core competencies of each laboratory and institution, and develop procedures for collaboration and cooperation.
4. You are concerned about the close relationship (privileged information to potential competitors) between the managing corporation and the laboratory with which you are interested in entering into agreement. Develop new ways and means to assuage your concerns by the implementation of changes to the federal laboratory management system.
5. Generate a concept, a strategy, and salient points of future legislation that will enable you to more adequately deal with federal laboratories.
6. Outline your concerns about unfair competition and negotiate them with all involved stakeholders.
7. Evaluate the tradeoffs between tax incentives for R&D and the availability of technologies, people, and facilities from labs and universities.
8. Develop ways in which the resources of the federal laboratory system will complement rather than compete with industry laboratories. Since long-term research performed by industry laboratories is declining, determine the feasibility for industry to rely more heavily on the federal laboratory system to provide long-term research germane to industry's needs in specific areas.

Foreign Countries:

You represent dignitaries and officials from industrialized and developing foreign countries, representing both industry and government. You are interested in pursuing new relationships between your countries and the United States relative to entering into new agreements which would be mutually beneficial to your countries and to the United States and, particularly, DOE's federal laboratories. You are currently contributing 15% of the industrial R&D performed in the US. Your investment has contributed to offsetting the extremely low savings rate in the US. However, you are also concerned about some political movements that seem isolationist and threaten to increase tariffs and restrict trade. You are also concerned about intellectual property ownership.

Challenges:

1. Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Determine which policies and technologies you wish to invest in.
4. Develop an overall strategy whereby your countries could acquire energy and other technologies created at the US federal laboratories and present proposals to the appropriate teams to realize these strategic objectives.
5. Determine how international technology transfer and technology licensing could more easily be realized from technologies

developed at federal research laboratories.

6. Define what your countries' core competencies are. Devise new ways to collaborate on technological development between your country and the US, especially on high-risk, high-payoff R&D investments (e.g., fusion, particle accelerators).

DOE Weapons Labs:

You represent the weapons laboratories (Sandia, Lawrence Livermore, Los Alamos). With the winning of the cold war, your mission has come under scrutiny. Although you have much to contribute to the nation's welfare, you are very concerned about the labs' future. Although national security and science-based stockpile stewardship are essential for the foreseeable future, they will probably not be adequate to maintain the quality of staff and facilities that you need.

Energy and environmental cleanup remain important missions. However, neither is viewed by the public with the same sense of urgency as the past national defense mission. The US public often maintains a crisis mentality that does not strongly support investments in impending but not immediate problems. However, you consider your capabilities to be a national resource to meet many national needs, and not just your current missions.

Congress has not unanimously accepted new missions, and budget cuts are almost certain. Attacks on DOE as the managing agency have not helped your situation.

In a period of great uncertainty, you must carefully define your missions and your customers, and educate the public and government on your capabilities and potential contributions. Simultaneously, you must develop partnerships with industry and universities to alleviate turf and funding issues, resolve questions of competition, and develop strong synergies.

Challenges:

1. Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Discuss plans and concerns about continuing to be the stewards of the nation's stockpile: safety, security, reliability, readiness.
4. Determine how weapons research and production, as well as all other programs, can be accomplished in a more cost-effective manner: how to increase productivity and lower costs? value of partnering? benchmarking? reducing duplication?
5. Seek appropriate collaborative agreements among the weapons laboratories and other federal laboratories, universities, industry, and foreign interests.
6. Discuss the current GOCO (Government-Owned, Contractor-Operated) management system and other alternatives, including sponsorship by DoD rather than DOE, privatization, or corporatization. How would the labs respond to these situations?
7. Determine what additional areas of research and development are appropriate to pursue within the weapons laboratories. Substantiate your conclusions. Pursue activities that would enable the weapons laboratories to perform such research.
8. Create brief position statements about the environmental cleanup requirements faced by DOE, determine appropriate objectives and strategies relative to the

weapons laboratories' capabilities in the area of environmental cleanup, and pursue activities appropriate to your conclusions.

DOE Other Labs:

You represent the DOE federal laboratories other than the weapons laboratories, including ANL, ASKC, BNL, INEL, LBNL, NREL, ORNL, and PNL. You have concerns with respect to the effectiveness of the laboratories' management system, the reported low morale among personnel, competition between labs and universities, and between the labs themselves, and whether or not the metrics or measurements of laboratory performances are adequate. You share many of the same concerns and problems as faced by the weapons labs, but you lack the continuing weapons mission. However, you consider your capabilities to be a national resource to meet many national needs, and not just your current missions.

Challenges:

1. Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Determine the major areas of R&D competence in your laboratories. Which areas should be pursued by which labs?
4. Create a strategy for successfully pursuing these areas of research on a long-term basis and implement this strategy.
5. Seek appropriate collaborative agreements with the weapons laboratories, other federal laboratories, industry laboratories, and university laboratories.
6. Assess the GOCO (Government Owned, Contractor Operated) management system, list suggested changes, and actively pursue these changes.
7. Create brief position statements about the environmental cleanup requirements for which DOE is responsible, determine appropriate objectives and strategies relative to possible laboratories' capabilities regarding cleanup requirements and pursue activities appropriate to your conclusions.
8. Suggest changes that would enhance personnel morale.
9. Develop a better system of measuring performances of the laboratories.
10. Determine the roles, if any, of your laboratories in long-range development of national sustainable energy sources.
11. Determine the roles, if any, of your laboratories in the development of the new field of "industrial ecology."

Universities:

Many universities, like federal laboratories, have departments or affiliated organizations that perform research and development. The federal laboratories and universities encounter similar obstacles in maintaining adequate funding, acquiring and retaining expert personnel, and receiving proper remuneration for the technologies produced. Due to funding reductions in government allocations and in university budgets, officials in both institutions encounter the problem of altering their operations to compensate for the reduced budget allocations. Political considerations are always germane. Educational trends, such as remote education, industries' disenchantment with higher educational institutions' products (graduates), industries' rapid technological change, the increase in the number of short-term tech-schools, and the rising cost of conventional education, present difficult challenges to universities. In many cases, you see the federal labs as your competitors, taking away resources that you feel could be better spent at universities. Your task is to consider the salient points in the rapidly changing educational field within the context of finding new ways to cooperate, joint venture or partner with federal laboratories and industry.

Challenges:

1. Outline your objectives, and the policies and technologies that will help you accomplish them.
2. Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
3. Suggest innovative ways in which universities and federal laboratories can cooperate that could solve some of the existing university problems and mutually enhance the probability of additional revenue for both.
4. Determine the most promising of these innovative possibilities, create a strategy for implementing these possibilities, and explore them within the context of the game.
5. Seek funding to support your strategies.
6. Explore the balance of domestic versus foreign funding of university research, and the implications of this split. List your concerns, if any, with respect to federally funded laboratories competing with university laboratories. Determine how these concerns could be resolved and take appropriate action to make these changes.
7. Explore concerns related to the licensing of intellectual property to foreign companies.
8. Negotiate with appropriate teams to implement your strategy and achieve your objectives.

Control Team and News Media:
Members of this team include representatives from various disciplines and fields, such as news media, legal, public relations. Members of this team will interact with members of other teams in such a manner as to simulate world reactions to events transacted by other team members. Members of this team can also be a resource to other players for such assistance as legal advice. Additionally, members of this team include staff who guide the game process.

Challenges:

1. Introduce activities into the game from your field of expertise as you determine.
2. Respond to inquires for assistance from other team players.
3. Exercise a veto over some team actions if necessary to maintain game integrity in accordance with the objectives.
4. Act as President of the United States.
5. Resolve all situations and problems.

TOOLKIT OPTIONS

Players have two ways in which they can alter the future. One is the conventional approach that involves negotiations and contracts among the stakeholders in a realistic process that evolves within the game. The other way is through Toolkit Options. These are a list of technology and policy options that teams and players can invest in. We have created a list of these options and assigned a total resource investment that would yield a 50% probability of success. Teams determine which of these technology and policy options are important for their desired futures. They invest their own resources and encourage others to partner with them, according to their priorities.

Teams are also allowed to create their own Options. “Experts” on the Control team will assign mean investments that would yield a 50% probability of a successful outcome. The procedure for creating your own Toolkit Options is discussed in the Rules of Play.

All investments must be completed and turned into Control by the end of Session 2. The results will be published at the start of Session 3. All successful technologies and policies will be implemented and become part of the environment of the game.
Toolkit Options provide an indication of some possible advances in technology, or policy

changes that might significantly help the teams accomplish their objectives. The Toolkit is a shortcut to accomplishing these objectives outside the normal processes. It is also meant to encourage collaboration among the many stakeholders and to indicate the highest priority technology and policy objectives of the players. Toolkit resources are not available for any other uses in the game. Investments made in unsuccessful options are permanently lost. *Toolkit investments are the responsibility of each team.* Each team must turn in its own Toolkit spreadsheet. The Toolkit options will also be posted on a wall board. Players are encouraged to enter their investments on the board, and observe the investment patterns of other teams. Since the board is unofficial, no team can hold another team liable for mistakes or investing differently from the board entries. However, formal agreements can be made between teams on investments (with Control's signature); violations of those written agreements can be litigated.

The outcomes of the Toolkit investments are determined probabilistically as shown in the example of Figure 4 (where the mean cost is 100). First, the baseline probability will increase with increasing investment following a normal distribution with mean x and standard deviation σ = x. For an option with a mean cost of 100, an investment of twice the mean, 200, would yield a success probability of 0.84. To take into account factors other than total investment, a uniform distribution is superimposed on the normal distribution to reflect uncertainties and risks in the real world for accomplishing major technology or policy breakthroughs. This uniform distribution can increase or decrease the baseline probability by as much as 16%. The minimum total investment for any option is one-half the mean.

The total investments from all teams are fed into the computer and the success or failure is determined by this process. A list of technology and policy options is shown in detail in Table 2.[3]

The teams can invest up to the maximum allocations shown in Table 2. Those resources represent the approximate dollars allocated (in millions) and relative influences of the different stakeholders. Toolkit credits that are not invested are lost; they cannot be used in any other way in this game.

Negative investments are permitted for policy options. If your team strongly opposes a particular policy, your negative investments can make the realization of that policy less likely. Negative investments are deducted from the team's credits as if they were positive.

Some Toolkit investments involve joint ventures or partnerships among several stakeholders. To be considered, all involved parties must invest some funds in the option. The investments need not be equal. E.g., a joint industry-labs-university program must have some funds invested by all three teams to be accepted.

Many more Toolkit investments have been provided than can be successful with the funds available. Hence, you should carefully consider which options are most important for accomplishing your objectives. These selections allow the assignments of the players' priorities to the many possible investments.

After the Toolkit investment period ends, a credit can be treated as equal to one million dollars to help estimate the mean costs of future investments.

[3] These options will be reproduced in spreadsheet form in the game. Teams can use Table 2 as a worksheet and then transfer their investment selections to the spreadsheets and turn them in to the Control team.

Figure 4. Probability of Successful Toolkit Option for Cumulative Investments

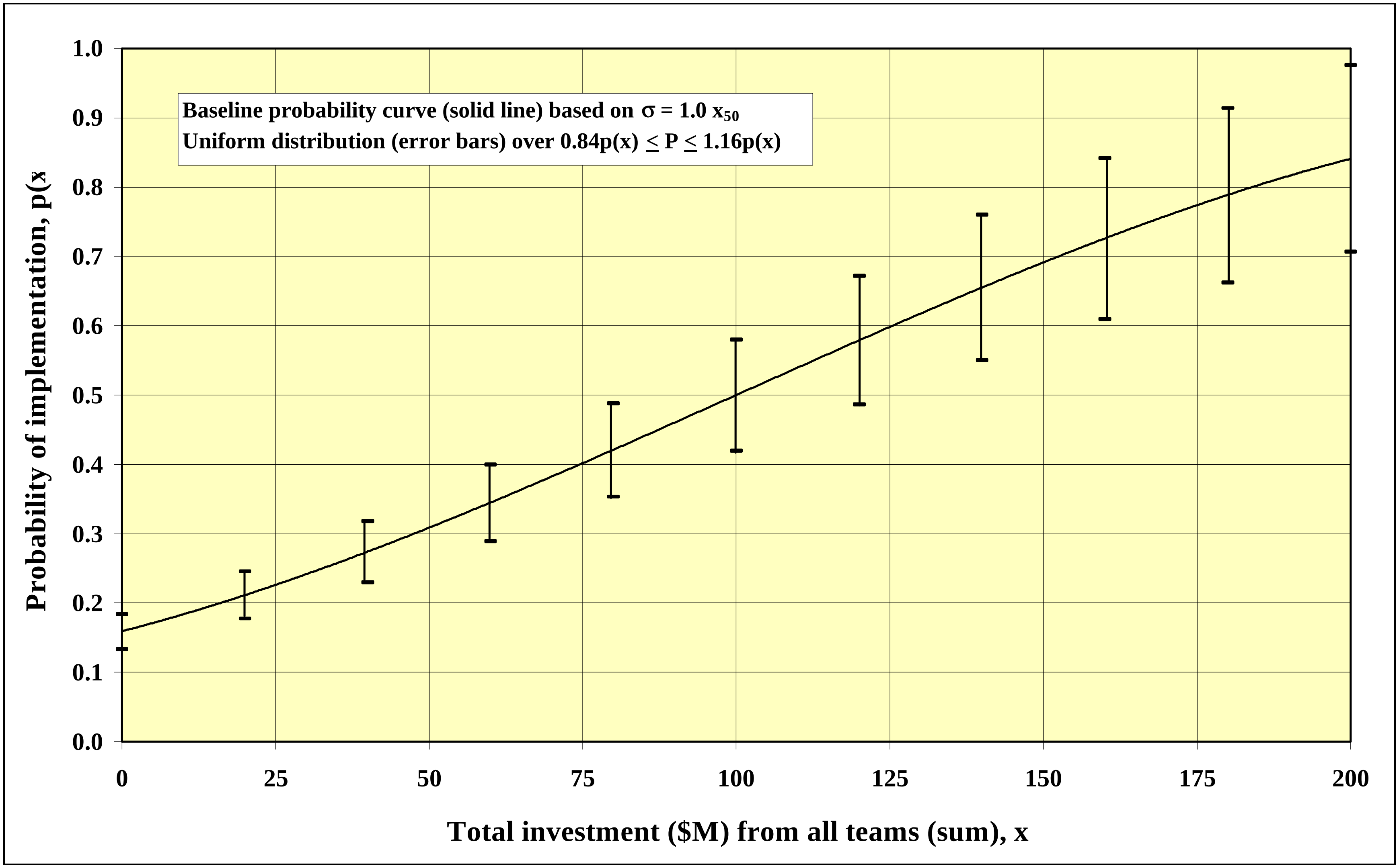


Table 2. TOOLKIT INVESTMENTS - DESCRIPTIONS OF TECHNOLOGY AND POLICY OPTIONS

Indicate the number of credits your team wants to spend for each option. Credits can be used to support or oppose any option. The investments by all teams will be added for each option to get a total investment. The probability of an option being implemented increases with the total investment for that option, so influencing other teams to partner with you will improve your chances for success. Negative investments are subtracted from the total for each option. Negotiations are strongly encouraged.

Team	Credits	Team	Credits
US Congress	550	Other Federal Agencies	150
US Industry 1 (IT/Mfg.)	300	DOE Weapons Labs	50
US Industry 2 (E/E)	300	DOE ER/EM Labs	50
US Industry 3 (LS/Mat.)	300	Universities	150
US Industry 4 (NS/CJ)	300	Foreign Government/Industry	300
Department of Energy	100	Control/Rest of the World	300

Technology and Policy Options — **Credits for 50% chance** — **Your offer**

Technology Investments

Example: A total investment of 200 credits in T1 will yield a success probability of 50% (an investment of 400 credits gives a success probability of 84%). Successful technology options will generate a return equal to 10% of the credits invested (10% is assumed to be the nominal R&D fraction of a profit stream) over the specified period; e.g. an investment of 400 credits in T1 would yield a return of 8 credits (or $8M) per year for 5 years if the option succeeded. Team returns will be proportional to initial investments.

Information Technology and Advanced Manufacturing

	Option	Credits for 50% chance	Your offer
T1.	The Accelerated Strategic Computing Initiative (ASCI) is continued, and a 15 teraflops machine is completed and available for use in the year 2000 (5 years).	200	_______
T2.	If T1 succeeds, ASCI is continued, and a 100 teraflops machine is completed and available for use in the year 2003 (5 years).	200	_______
T3.	Industry becomes a partner in the ASCI program by contributing funding and expertise (2 years).	50	_______
T4.	A major new program is launched to ensure the integrity and security of the national information infrastructure and telecommunications system to protect both government and business transactions (3 years).	150	_______
T5.	Advances in bandwidth, software, and related technologies allow virtual work environments to become practical with applications to the workplace and education (4 years).	250	_______
T6.	A joint laboratory-university program is created to develop and deploy new technologies to reduce costs and increase quality of education in US schools (K-12) and colleges (4 years).	200	_______
T7.	Industry becomes a partner in the Advanced Design and Production Technologies (ADaPT) program by contributing funding and expertise (2 years).	50	_______

T8. The DOE, DOD, DOC, labs, industry, and universities establish a virtual enterprise to cooperate on technology projects similar to the Technologies Enabling Agile Manufacturing (TEAM) effort. Each investment here is for a specific agreed-upon project (like agile manufacturing, sensor technology, advanced photonics, etc.) (5 years). 100 _______

T9. The DOD funds a joint industry-government R&D effort on microelectro-mechanical systems (3 years). 120 _______

T10. The US launches a national program to develop and deploy intelligent control and traffic management systems at local and regional levels. 60 _______

Energy and Environment

T11. DOE sponsors a program that increases the efficiency of the use of gasoline by 10% (5 years). 50 _______

T12. A joint industry-labs-university program is launched to develop alternative efficient and clean fuels for vehicles (5 years). 300 _______

T13. US participation in the International Thermonuclear Experimental Reactor (ITER) program is fully funded (10 years). 1000 _______

T14. DOE creates a national program to develop and deploy new environmental cleanup technologies at the national labs (5 years). 300 _______

T15. The US launches a jointly funded (industry-government) national program to encourage the replacement of current manufacturing processes with “sustainable” processes - i.e., industrial ecology (3 years). 150 _______

T16. The US launches the National Water Initiative to develop systems for cleaning and recycling water (10 years). 300 _______

T17. A Global Clean Water Initiative is funded to cheaply convert sea water to fresh water. This includes evaluation, risk/cost analyses, engineering, and prototyping (10 years). 300 _______

T18. A risk/cost basis for analysis of safety and environmental regulations is developed and widely accepted for use (6 years). 100 _______

Life Sciences and Advanced Materials

T19. A joint industry-labs-university program is launched to develop home health monitoring systems (2 years). 50 _______

T20. A joint industry-labs-university program is funded to develop software for diagnosis, epidemiological studies, remote consultation and diagnosis (telemedicine), and health management, and to place these tools on the Internet with secure technology (3 years). 60 _______

T21. A beta version of a new telemedicine protocol is successfully tested in 10% of the US. This includes the central hardware and system-wide software and security necessary for operation (4 years). 250 _______

T22. Biomimetic materials prove to be outstanding in innovative building and manufacturing processes. NIH and NSF jointly fund research into new applications (6 years). 300 _______

T23. Research in enhanced recombinant DNA technologies increases food production by 20% in the US and by 100% in developing nations (6 years). 200 _______

T24.	A joint industry-labs-university program is launched to develop smart materials for construction and manufacturing that give visible or audible warnings when they become unsafe (5 years).	100	_______
T25.	To improve the nation's transportation infrastructure, a joint industry-labs-university program is launched to improve the safety and durability of roads and bridges (10 years).	300	_______

National Security and Criminal Justice

T26.	If T1 succeeds, a virtual weapons test (3-D, large mesh) is demonstrated with the 15 teraflop machine using an advanced hydrocode (4 years).	100	_______
T27.	To meet the needs of a secure nuclear weapons stockpile in the absence of testing, the National Ignition Facility is approved for construction (5 years).	800	_______
T28.	Accelerator-produced tritium is chosen over a new reactor (5 years).	800	_______
T29.	DOE concludes agreement with the commercial nuclear reactor industry to insert tritium-producing systems into commercial reactors to provide tritium for all future weapons needs, obviating the need for new accelerators or reactors for tritium production (5 years).	160	_______
T30.	The DOE decides to upgrade one of its existing facilities to enhance the US neutron research capability. The DOE chooses which one (4 years).	200	_______
T31.	A joint DOD-laboratory-university program develops system-level technology to detect, evaluate, and neutralize metal land mines (6 years).	100	_______
T32.	A safety tracking system using an encryption chip is developed. The chip and system are to be used for shipping, materials control, and child and prisoner tracking (6 years).	150	_______
T33.	A new program is launched to use the labs technology capabilities to enhance the security and safety of citizens from internal threats like crime and terrorism (10 years).	300	_______
T34.	A Disaster Minimization program is launched to explore ways to prevent or mitigate damage from natural disasters such as earthquakes, floods, and hurricanes (10 years).	400	_______

Policy Investments

Certain policies, if successful, may also yield financial returns to the investing teams.

P1.	Congress decides to create a lab-closing board similar to the base closure commission.	50	_______
P2.	Congress closes two national laboratories and decides on which ones.	50	_______
P3.	DOE decides to create and implement a "Lead Laboratory" concept. They develop this in conjunction with the labs and propose the ideas to Congress.	50	_______
P4.	DOE authorizes the creation of a "System of Labs." The labs and DOE develop and implement the concept.	100	_______
P5.	The DOE weapons labs are placed under the Department of Defense.	100	_______

P6.	Several labs are privatized. Congress, DOE, industry, and the labs decide on which ones.	50	_______
P7.	The FFRDC legislation is repealed. All national labs are required to compete on an equal basis with universities and private industry, with no level-of-effort funding; all government property and infrastructure are transferred to the labs. This essentially privatizes all labs.	150	_______
P8.	The non-weapons labs arecorporatized and operated by a new non-profit corporation. Funding would come by line-item through the congressional budget.	50	_______
P9.	All DOE labs arecorporatized and operated by a new non-profit corporation. Funding would come by line-item through the congressional budget.	100	_______
P10.	The non-weapons labs are eliminated and all their facilities and equipment are auctioned to universities, industry and foreign governments. Lab staff are provided generous lay-off allowances based on seniority.	200	_______
P11.	Congress expands the missions of some national laboratories to include two-way technology transfer (to and from industry) in a mutually beneficial process controlled and orchestrated by the labs.	100	_______
P12.	Congress removes all funding for tech transfer initiatives at the labs.	50	_______
P13.	The labs are assigned the responsibility for evaluating all environmental regulations to ensure that they are science-based and cost-effective.	100	_______
P14.	Congress adds biotechnology as a new mission for the national labs.	100	_______
P15.	Congress adds internal security and safety as a new mission for the national labs to use technology to improve all aspects of the criminal justice system: crime prevention, criminal apprehension, evidence, incarceration, etc.	100	_______
P16.	Congress creates a new Department of Science that includes all science and technology R&D currently done at DOE, DOC, NSF, and other federal agencies.	100	_______
P17.	The DOC is abolished.	100	_______
P18.	The DOE is abolished.	100	_______
P19.	DOE and DOC are combined to manage all existing responsibilities and to create synergistic facilities and programs.	100	_______
P20.	Congress reduces funding to all the labs by 30% across the board over 5 years.	40	_______
P21.	Congress increases non-defense R&D spending by 5% per year through the year 2000 by means of a slight tax increase .	300	_______
P22.	Congress reduces non-defense R&D spending by 5% per year through the year 2000 and implements a slight tax decrease.	50	_______
P23.	Congress implements sin taxes of $1 per pack of cigarettes and $1 per liter of hard liquor to increase non-defense R&D funding by 5%.	150	_______
P24.	Congress increases the federal gasoline tax by $0.10 per gallon. The resulting revenue (3% increase) will fund new R&D on energy (sources, efficiency, etc.)	100	_______
P25.	Congress passes legislation to remove all impediments to deployment of advanced information and telemedicine systems across state boundaries by creating a national licensing system for medicine.	200	_______
P26.	Congress creates a major program to measure the results and return on investment of all government R&D programs.	100	_______

P27.	Congress establishes a virtual replacement for the Office of Technology Assessment (OTA), managed by the labs, and pulling resources from universities, labs, and industry to respond quickly to Congressional questions.	50	_______
P28.	Congress authorizes DOE to benchmark other national technology delivery systems and laboratory approaches (e.g., Fraunhofer in Germany, the ministries in Japan, the 12 labs in Singapore, etc.) and report back to Congress with recommendations.	50	_______
P29.	DOE and Congress develop the will and the funding to solve the nuclear waste disposal problem in 5 years.	500	_______
P30.	R&D tax credit is made permanent and joint industry-national laboratory and/or university efforts are included as eligible for the credit.	50	_______
P31.	Specific companies and the laboratories negotiate a program to create temporary assignments of lab staff to industry and vice versa. Program is jointly funded by industry and the DOE. This option requires an agreement among the following teams for implementation: DOE, Industry/Companies, Congress, both Labs teams, Other Federal Agencies.	100	_______
P32.	Congress reforms the product liability system to create incentives for technological innovations in transportation, biomedical technologies, etc.	200	_______
P33.	Congress repeals the Glass-Steagall act and removes all regulatory barriers preventing banks from owning equity in companies.	100	_______
P34.	The Bayh-Dole Act is amended to remove giving automatic title to intellectual property to university, not-for-profit and small-business partners. However, they have the right to negotiate appropriate licenses.	50	_______
P35.	Congress decides that it will only fund basic research at universities or institutions managed by universities. The labs must focus only on mission-related, applied research and development.	200	_______
P36.	Mutual defense pacts with allies are written to include broad technology-sharing agreements. This option requires an agreement among the following teams for implementation: DOD (Other Agencies), Congress, Weapons Labs, and Foreign.	100	_______
P37.	The National Technology Transfer Act (including the restrictions on national labs giving intellectual property rights to foreign entities) gets amended.	50	_______
P38.	The Bayh-Dole Act is amended to make it consistent with the 1989 Technology Transfer Act , thereby banning universities from licensing or selling intellectual property to foreign entities.	50	_______
P39.	Congress authorizes DOE to work together with foreign countries, labs and universities to conduct coordinated research on global environmental problems.	100	_______
P40.	A new multi-stage standard setting program in created and adopted. This includes development of on-line archives and would support proposal, voting, development, and creation of new industry standards.	80	_______
P41.	Foreign companies acquire preferential and exclusive rights to the results of federally funded research at US universities by contributing to university facility, teaching and R&D needs to replace lost federal funds.	200	_______
P42.	Foreign companies create US-managed venture capital firms to obtain access and manufacturing rights to technologies developed at labs and universities.	200	_______

MONEY

Money serves several very important functions in this game, including:

- representing the scarcity of resources and the need to prioritize investments;
- approximating the relative influence of the different stakeholders;
- providing a method to treat the real risks involved in R&D investments;
- approximating the flow of money in the real world;
- helping to distinguish between customers (R&D funders) and suppliers (R&D performers);
- establishing a basis for negotiations, partnerships and joint ventures;
- providing an anchor to reality.

However, it is important that money not overly interfere with the creativity of the players, and the development of new strategies to meet the teams' challenges and objectives. Winning the game does not *necessarily* mean accumulating the most money. Winning is accomplishing the game objectives and the players' objectives, and translating the learning and experimentation into real-world solutions.

Based on our experience, we have introduced several simplifications into the distribution chain of funds by preallocating funds. However, all teams have the same prerogatives as they do in real life.

In this game, industry is assumed to also represent all workers, and hence is the ultimate source of most income in the game. Congress is assumed to levy a 50% tax on all industry income. In turn, Congress allocates its funding to the federal agencies (DOE, OFA), who in turn provide funding for the labs, universities, and industry. The assumed funding chain is shown in Figure 5. The figure also shows that the teams may alter or redirect their spending and income with agreements executed during the game (both black and gray arrows). Funding teams can change assumptions over the course of the game by notifying the Control team. Changes are then implemented in the subsequent sessions. Table 3 shows the six teams at the "top" of the food chain, and their projected income over the course of the game. Table 4 shows the assumed percentage, source and dollar projections for the teams lower in the food chain, and how the agencies are assumed to distribute their funds. Congress must distribute all of its funds through its agencies.

Changes may also be made beyond the allocation table. For example, Congress may decide to reduce spending on entitlement programs and increase R&D (or vice versa); this will be allowed if the President (Control) concurs.

Table 3. PRIMARY FUNDING SOURCES ($M) (pretax)

Team	Fraction of National Expenditures and Source	Session 3 1998-1999	Session 4 2000-2001	Session 5 2002-2003
US Industry 1	0.42% of Industry R&D	699	671	645
US Industry 2	0.14% of Industry R&D	233	224	215
US Industry 3	0.14% of Industry R&D	233	224	215
US Industry 4	0.14% of Industry R&D	233	224	215
University R&D	0.75% of Endowments, etc.	103	100	98
Foreign R&D in US	0.50% of For. Cos. In U.S.	160	160	160
	Totals =	**1661**	**1603**	**1548**

Figure 5. Flow of Money in the Game

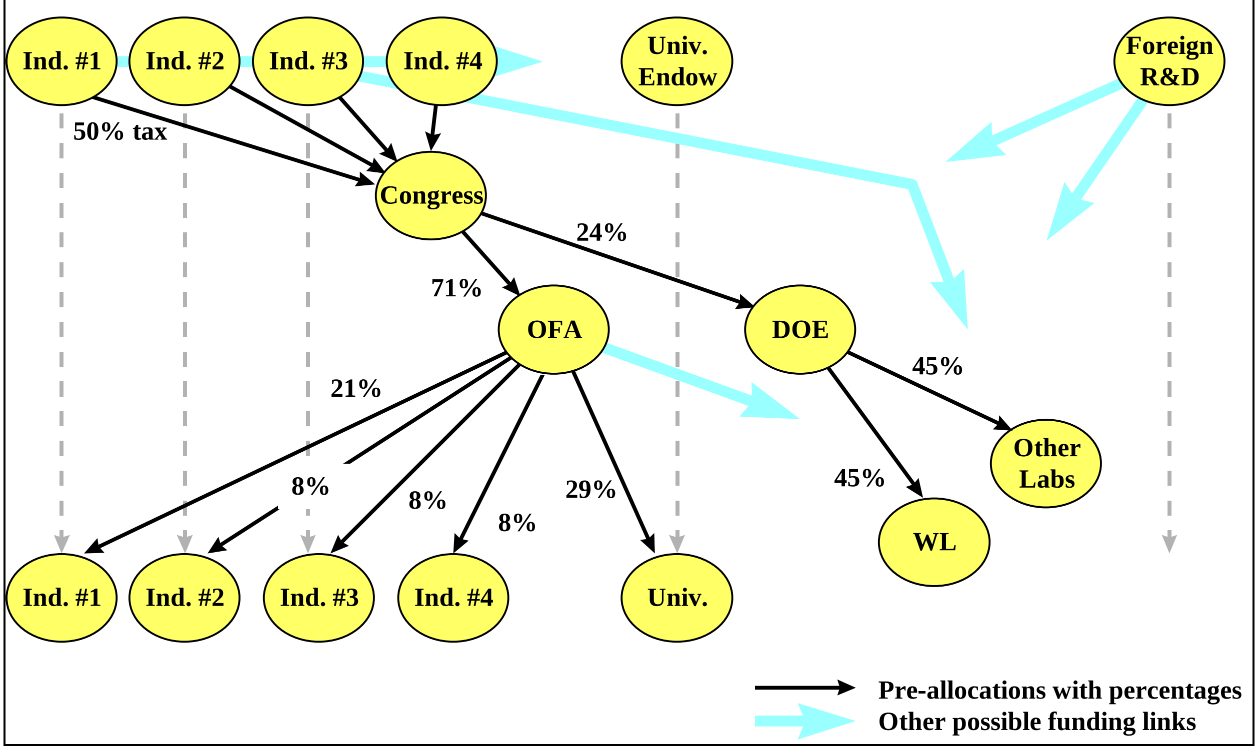


Table 4. FUNDING "FOOD CHAIN" - SOURCES AND RECIPIENTS ($M)

Funding and Receiving Teams	Funds to:	Session 3 1998-1999	Session 4 2000-2001	Session 5 2002-2003
Congress taxes Industry	50% to Congress	699	672	645
Congress funds DOE	24% to DOE	168	161	155
Congress funds Other Agencies	71% to Other Federal Agencies (OFA)	496	477	458
Congress discretionary	5% to Congress	35	34	32
DOE funds Weapons Labs	45% to Weapons Labs	76	72	70
DOE funds Other Labs	45% to Other DOE Labs	76	72	70
DOE discretionary	10% to DOE	16	17	15
OFAs fund Industry	21% to Industry 1	104	100	96
"	8% to Industry 2	40	38	37
"	8% to Industry 3	40	38	37
"	8% to Industry 4	40	38	37
OFAs fund Universities	29% to Universities	144	138	133
OFAs discretionary	26% to OFA	128	125	118

The final allocations, i.e., the results of this food chain, are shown in Table 1, page 7.
Please discuss with your facilitator any questions you might have concerning the allocation of funds and your team's prerogatives.

RULES OF PLAY

CONTRACTS:

Contracts or agreements can be carried out between any two or more teams. Contracts must describe an exchange of value for value. All contracts must use the standard form (see Figure 2, page 5) and be legibly written. Agreement forms should be filled out from the top down. The 50% cost should be obtained from Control before final commitments are made. Team representatives should bring the written contract to the Control team for final approval; a member of the Control team must sign and date the agreement for it to be valid. If the success or failure of the contract is determined probabilistically, Control will perform the necessary calculations and report the results to the parties immediately. Success or failure will be determined by sampling from a normal distribution with the actual sum invested, just as was done for the Toolkit investments. For example, investing twice the median estimate will produce a base probability of success of 84.1%; superimposed on this probability is another uniform probability distribution that represents uncertainties and risks that are not necessarily reduced by larger investments.

DISPUTES:

All disputes will be resolved by the Control team, whose decisions are binding.

LAWSUITS:

Lawsuits can be filed at any time by any team. An odd number (at least 3) of judges must hear the case. After both sides have presented their arguments, the judges decide by majority rule. Judges' decisions are final and binding. Litigants must appear before the judges at their scheduled times. If one litigant is one minute late, a judgment will be immediately rendered in favor of the litigant who is present. If both litigants are five minutes late, the case will be dismissed; the litigants will need to reschedule their court times.

SCHEDULES, APPOINTMENTS

It is essential that all players strictly follow the agenda and be on time for their appointments. Penalties can be assessed for players or teams that are late.

TOOLKIT OPTIONS

Investments in Toolkit options must be turned in before the deadline. Investment amounts should be legibly written on the Toolkit forms. Completed forms must be submitted to the Control team prior to the deadline. Players and teams cannot exceed their maximum total investments shown on the forms. Results of the investments will be announced and implemented into the play of the game. Only one opportunity is available for Toolkit investments.

Teams or players who wish to create **new options** must follow these steps:

1. Write up option clearly;
2. Discuss it with a designated member of the Control team; if accepted, Control will assign a median probability cost;
3. Provide all investors with written copies of the new option, together with the amount they will invest, and the signature of the team facilitator;
4. Bring option and investments to Control before deadline.

Marketing of new options to other teams is the responsibility of the initiating team. New technology investments outside the Toolkit follow a similar process.

APPENDIX A: LIST OF PLAYERS AND STAFF

NAME	ADDRESS	PHONE #	FAX #	ROLE
US CONGRESS				
Clemons, Steven C.	Sr. Policy Advisor, Office of Senator Bingaman, 703 Hart Senate Office Bldg., Washington, DC 20510	202-224-4266	202-224-2852	
Comer, Douglas B.	Staff Director, U.S. House of Representatives, Technology Subcommittee, 2320 Rayburn House Office Bldg., Washington, DC 20515	202-225-8844	202-225-4438	
Gilman, Paul (Dr.)	Executive Director, Commisson on Life Sciences, National Research Council, 2101 Constitution Ave. NW, Washington, DC 20418	202-334-2500	202-334-1639	
Hyer, Randall N. (Dr.)	Congressional Fellow /Senator Domenici's Office, SHOB-328, Washington, DC 20510	202-224-2522	202-224-7371	
Triplett, William	Counsel, 431 Dirksen Building, Washington, DC 20510-4403	202-224-5444	202-224-4908	
Van Cleave, Michelle (Esq.)	Counsel, Feith & Zell, PC, 2300 M Street NW, Suite 600, Washington, DC 20037	202-293-1600	202-293-8965	
Weimer, R. Thomas	Staff Director, House Committee on Science, Subcommittee on Basic Research, 2320 Rayburn House Office Bldg., Washington, DC 20515	202-225-9662		
Yochelson, John	President, Council on Competitiveness, 1401 H Street, NW, Suite 650, Washington, DC 20005	202-682-4292	202-682-5150	
Narath, Shanna S.	SNL, MS1378, P.O. Box 5800, Alb. NM 87185-1378	505-843-4285	505-246-2891	Facilitator
Traeger, Richard	SNL, MS0131, P.O. Box 5800, Alb. NM 87185-0131	505-844-2155	505-844-8496	Analyst
US INDUSTRY - 1: INFORMATION TECHNOLOGY AND ADVANCED MANUFACTURING				
Arnone, Patrick	VP-GM Public Sector Group, Sybase, Inc., 6550 Rock Spring Drive, Suite 800, Bethesda, MD 20817	301-896-1790	301-896-1601	
Bosco, Harry L.	Vice President, AT&T-NS Architecture, 200 Schulz Drive, Red Bank, NJ 07701	908-224-3001	908-224-3050	
Bottoms, Wilmer (Dr.)	Senior Vice President, Patricof & Company, 2100 Geng Road, Palo Alto, CA 94303	415-494-9944	415-494-6751	
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APPENDIX B: ADDITIONAL INFORMATION

B-1: Science, Technology, and Society
Marshall Berman

Almost all human progress is a result of science and technology. Science is "systematic knowledge of the physical or material world gained through observation and experimentation." Technology is "the application of knowledge for practical ends." Without science and technology, humans would still live in gatherer societies, unable to hunt without tools, or cook and stay warm without fire. It is clear that science and technology are fundamental to human existence and progress.

The enormous improvements in the quality and duration of life in the last few centuries are results of science and technology (S&T). Despite this, some people have begun to question the need for S & T, the level of private and public support for it, and the impact of technology on the environment. Whereas S&T were once seen as public investments in economic and social progress, they are now seen by some as expenditures, as consumption of scarce resources no different from other social costs. Some even consider S&T as a potential menace in need of control and limitation.

Attacks on S&T expenditures and science itself have arisen out of a confluence of economic and social trends including: pressures to reduce government spending, corporate emphasis on rapid return on investments, international competition, poor science education, widespread public science and math illiteracy, and some extreme elements of certain societal movements such as multiculturalism, feminism, environmentalism, animal rights, alternative medicine, and social reconstructionism.[4] Although the vast majority of scientists and engineers have ignored these trends, that may no longer be possible.

Science education is declining or under direct attack. In 1914, science and math composed 16% of a typical college graduate's training; today, they make up less than 6%. New bills have been introduced into the Tennessee House and Senate that would again make it a crime to teach evolution.

The need for a stronger link among science, technology and society has been recognized by many in the science, political, and academic community. "Science, Technology and Society" (STS) is now a recognized major at Stanford University. Similar programs have been developed at MIT, Cornell, Vassar, Penn State, and in other countries (Canada, England, Norway, Sweden, Holland and Austria). The Stanford STS degree program (B.A. or B.S.) is "predicated on the belief that science and technology are two of the most potent forces for individual, societal, and global change in the contemporary era."

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[4] E.g., see John Maddox, *Nature*, **368**, 185; (17 March 1994); Paul Gross and Norman Levitt, *Higher Superstition The Academic Left and Its Quarrels with Science*, Johns Hopkins University Press, 1994; Richard Nicholson, *Science* **261,** 143, (9 July 1993); Gerald Holton, *Science and Anti-Science*, Cambridge, Mass., Harvard University Press, 1993.

It is intuitively obvious that S&T ultimately increase the quality of life and the standard of living of the population. However, quantification of this causal link is extremely difficult because of the multitude of other factors that influence macroeconomic measures and because of the time delays between innovation and availability of different technologies.

Moral support for the benefits of S&T does not directly translate into solutions of pragmatic questions: what level of support is appropriate; what fraction should be supported at public expense; what topics should be pursued; who among the S&T performers (universities, industry, national laboratories) should perform different types of R&D; whatsynergies are possible; where are efforts redundant; how should multidisciplinary high-risk research be funded and performed. In the US, answers to these questions can form the framework of a national science and technology delivery system. This Prosperity Game is intended to initiate an exploration of these questions. The ideas, problems and opportunities developed here can be converted into important actions to help support and use science and technology in the best interests of the country.

Figure B-1 shows the allocation of federal expenditures in 1994. Federal R&D expenditures for that year represented only 4.5% (about $67B) of the total, with 1.9% (about $28B) non-defense related. Social Security, Medicare and Medicaid and spending on other Human Resources accounted for 59% of outlays (about $860B).

Figure B-2 shows historical and projected data on federal receipts and outlays in actual dollars. The projections are from the President's 1997 budget proposal, estimated to be in balance by 2002.

Additional economic data and the basis for the funding allocations in this game are provided in the next section on R&D Economics: History and Projections.

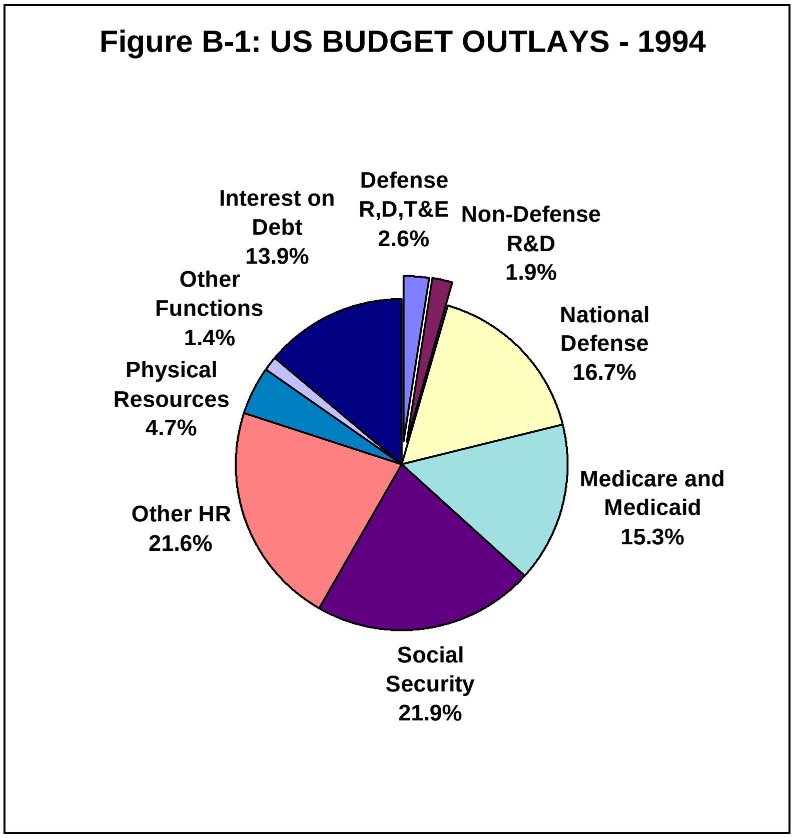
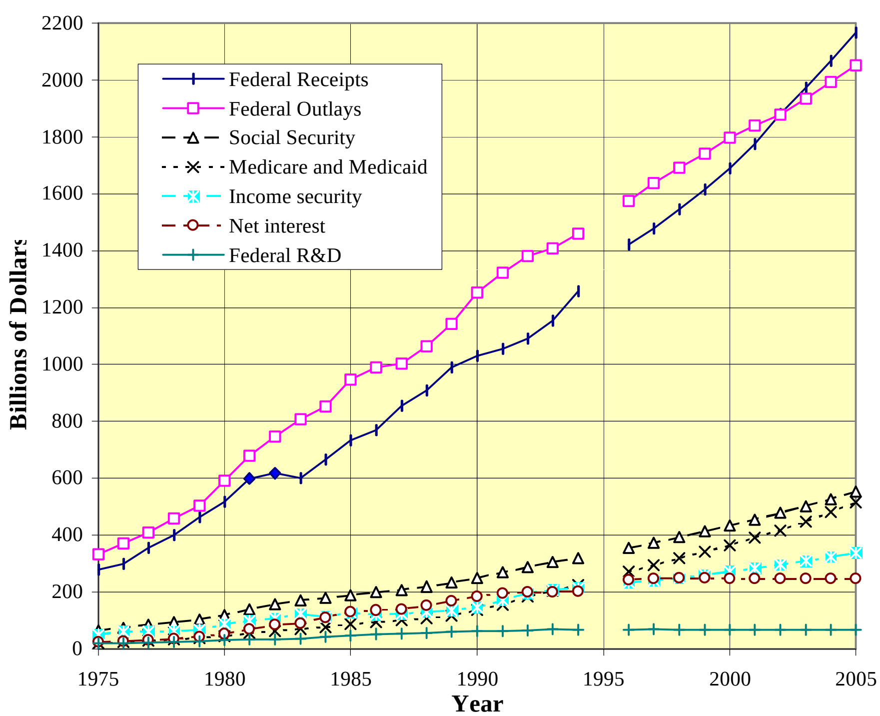


Figure B-2: Federal Receipts and Outlays



B-2: R&D Economics: History and Projections
Kevin Boyack

The money allocations in this game are based upon projections using the President's budget proposal for 1997[5], which calls for a balanced budget in 2001. Projections for other R&D spending, industry figures, and personal savings were based on historical data collected by the National Science Foundation[6] and the Bureau of Economic Analysis (US DOC)[7]. Although the data gathered from all sources was in dollars, we have converted all values to 'Constant 1996 dollars' to remove the effects of inflation from the game, and to highlight real growth rates (positive or negative) in spending. Some of the data are presented in Table B-1.

TABLE B-1. PROSPERITY GAME BASELINE ECONOMIC PROJECTIONS in CONSTANT 1996 $ (BILLIONS)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Scale to:
GDP	**7336**	**7490**	**7659**	**7832**	**8002**	**8184**	**8364**	8548	8736	8928	
Real Growth (GDP)		2.10%	2.25%	2.26%	2.18%	2.27%	2.20%	2.20%	2.20%	2.20%	
Federal Receipts	**1427**	**1453**	**1492**	**1520**	**1551**	**1584**	**1619**	1653	1689	1725	2.2%
Federal Outlays	**1572**	**1589**	**1584**	**1579**	**1576**	**1576**	**1581**	1592	1603	1614	0.7%
Social Security	**348.1**	**354.5**	**362.4**	**369.4**	**376.9**	**384.5**	**392.3**	400.3	408.5	416.8	2.1%
Medicare/Medicaid	**269.8**	**284.7**	**296.4**	**305.4**	**313.6**	**325.5**	**336.3**	347.4	358.9	370.8	3.4%
Income Security	**228.3**	**230.0**	**231.5**	**233.0**	**236.4**	**234.3**	**238.4**	242.1	245.8	249.7	1.6%
Net Interest	**241.1**	**231.8**	**223.2**	**215.7**	**205.7**	**197.5**	**189.0**	181.1	173.5	166.3	-4.3%
Federal R&D	**68.5**	**67.2**	64.5	62.9	62.0	60.7	60.2	59.2	58.3	57.3	-1.7%
DOE Weapons Labs	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	FedR&D
DOE ER/EM Labs	2.8	2.7	2.6	2.5	2.5	2.4	2.3	2.3	2.2	2.1	FedR&D
To Industry[2]	20.5	20.1	19.7	19.3	18.9	18.5	18.2	17.8	17.4	17.1	FedR&D
To Universities[2]	12.8	12.4	12.1	11.8	11.5	11.1	10.7	10.4	10.1	9.8	FedR&D
DOD, non-R&D	228.6	215.8	207.1	202.7	202.1	198.9	200.4	198.9	197.3	195.8	-1.0%
DOE, non-R&D	10.9	10.5	9.5	8.3	7.0	7.1	6.8	7.1	6.9	6.7	-3.0%
Other Federal	177.1	194.7	189.7	181.3	171.9	167.6	158.0	156.1	153.9	150.7	
Federal Deficit	**-145.6**	**-136.2**	**-92.6**	**-59.2**	**-24.7**	**7.2**	**37.2**	61.0	85.6	110.8	
US Industry Gross Profits[3]	578.4	590.6	603.8	617.5	630.9	645.3	659.5	674.0	688.8	703.9	GDP
Net Profits[3]	355.1	362.6	370.7	379.1	387.4	396.2	404.9	413.8	422.9	432.2	GDP
Undistributed Profits[3]	133.0	135.8	138.8	142.0	145.1	148.4	151.6	155.0	158.4	161.9	GDP
Industry R&D (source)[2]	103.5	101.8	100.0	98.4	96.7	95.1	93.5	92.0	90.4	89.0	
US Companies	87.5	85.8	84.0	82.4	80.7	79.1	77.5	76.0	74.4	73.0	-2.0%
Foreign Companies	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	0.0%
University R&D (source)[2]	7.1	7.0	6.9	6.8	6.7	6.6	6.5	6.5	6.3	6.3	-1.8%
Personal Savings[3]	224.0	219.5	215.1	210.8	206.6	202.5	198.4	194.5	190.6	186.8	-2.0%

The **bolded** data in Table B-1 are from the 1997 budget proposal. Data for the DOE Labs and for federal R&D funds going to industry and universities are projected from the NSF data and trends in discretionary funds from the 1997 budget proposal. The other data are projections based on historical or projected data from the indicated source, scaled to the 1997 budget numbers if necessary. The final column in the table gives some indication as to the method used for projection. A percentage rate indicates an average, though

[5] The Budget of the United States Government, Budget Supplement and Historical Tables, FY1997. (http://www.doc.gov/BudgetFY97/index.html)

[6] National Patterns of R&D Resources, 1995 Data Update. (http://www.nsf.gov/sbe/srs/s2195/start.html)

[7] National Income and Product Account Tables: 1959-95. US DOC. BEA. (gopher://una.hh.lib.umich.edu:70/11/ebb)

not constant, growth rate from year to year. *FedR&D* and *GDP* indicate rough scaling to the changes in Federal R&D spending and the GDP, respectively.

Graphical representations of these projections, as well as historical data from 1975-1994, are given in four charts below. All are given in terms of Constant 1996$ to show real changes. The 1995 data have been omitted from the charts to highlight the shift from historical to projected data.

Figure B-3 shows that the President's proposed balanced budget is to be achieved primarily through spending cuts, but without substantially slowing the growth of Social Security or the Medicare and Medicaid programs. Much of the proposed spending cut (approximately 50%, based on comparison of the President's 1996 and 1997 budget proposals) is to be accomplished through reduction of 'Net interest.' Net interest projections are heavily tied to economic assumptions. The President's 1997 budget assumes that the interest rates that the government pays on Treasury bills and notes will decrease significantly over the next seven years, at rates that are less than those used in the 1996 budget by 0.4% to 1.4%, depending on the year. The only thing certain about these projections is their uncertainty.

Equally as uncertain are the budget projections for real growth in GDP and in the consumer price index (CPI) as shown in Figure B-4. While the projections for real growth are comparable to the 20-year average of 2.5±2.2%, those for inflation are significantly lower than the 20-year average of 5.3±2.6%; the inflation projections are heavily weighted by the very low inflation rates of the last few years. The history of GDP growth shows very large fluctuations that cannot be captured in future projections. Figure B-4 also shows that the fraction of GDP used for R&D has been decreasing for several years, and may drop below 2% by

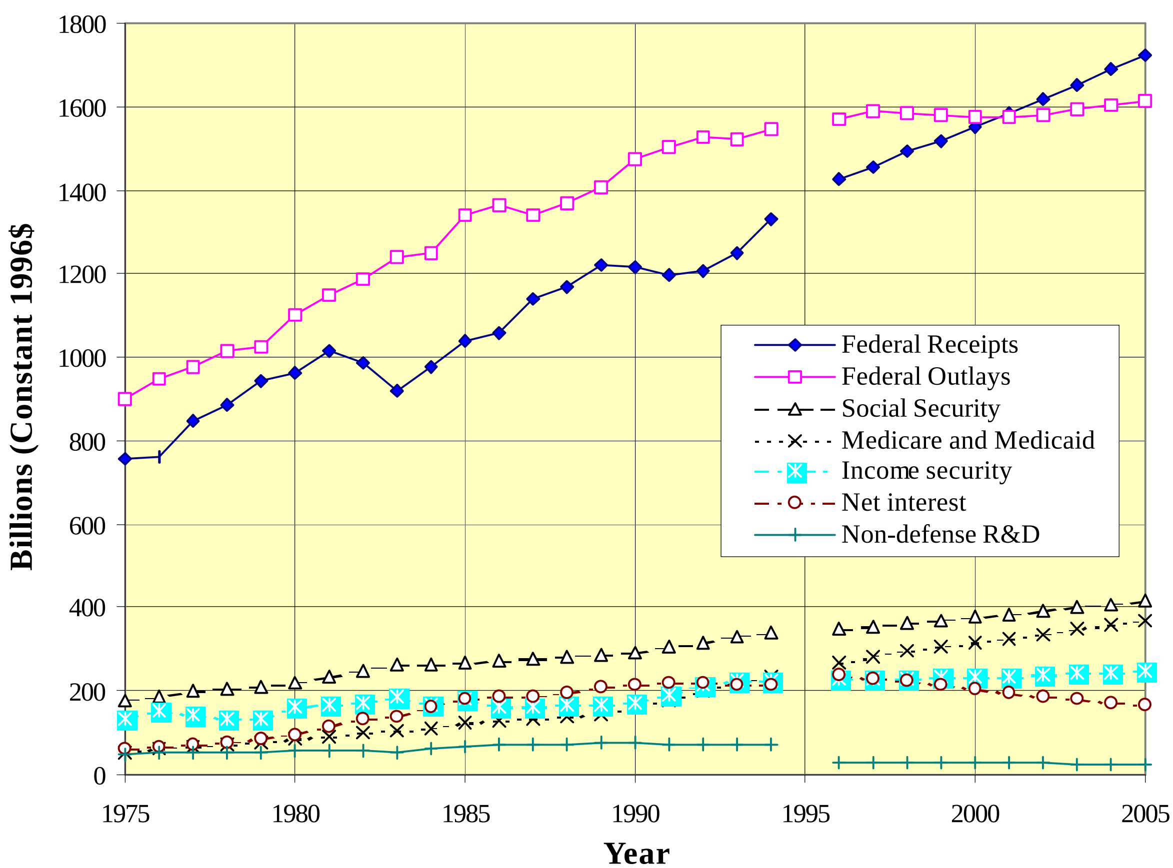


Figure B-3. Historical and Projected Federal Receipts and Spending.

the year 2001.

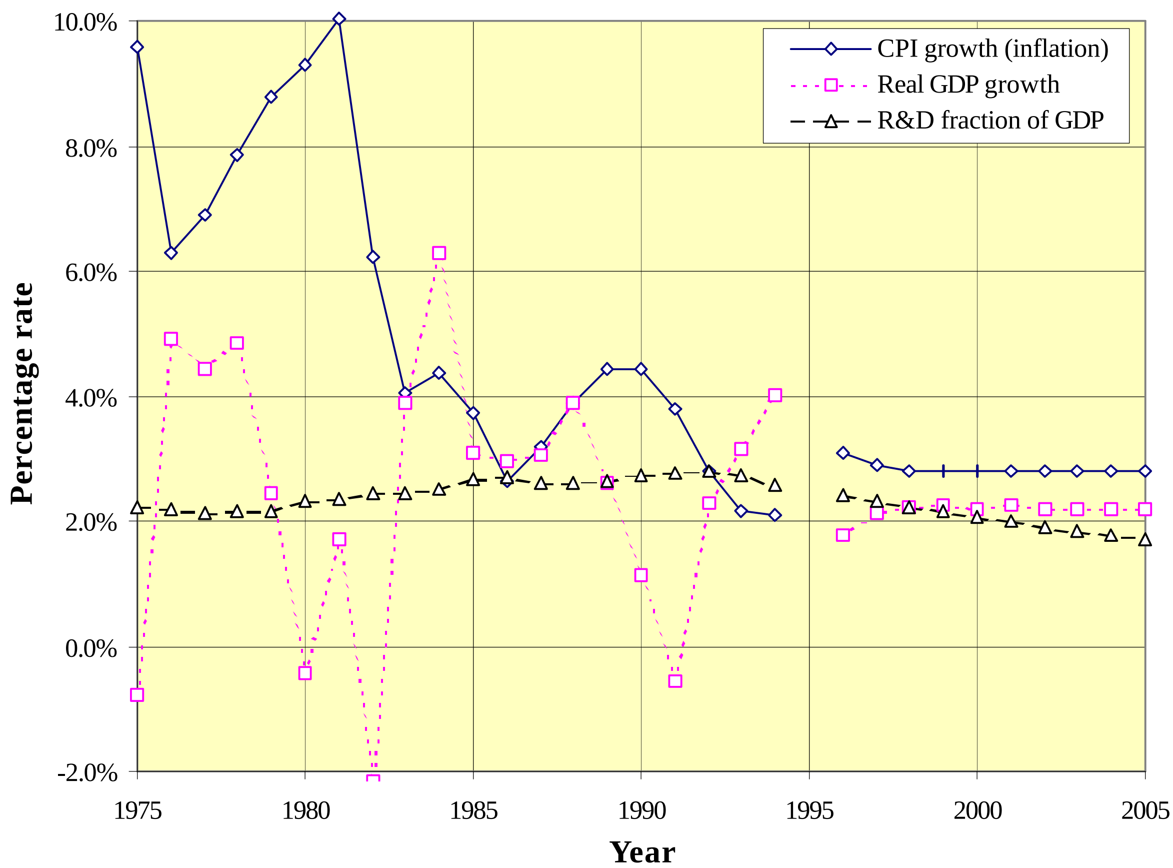


Figure B-4. Historical and Projected Growth, Inflation, and R&D Investment Rates.

Spending on R&D in the United States in real terms is also on the decline as shown in Figure B-5. With the pressure to balance the budget within seven years, it is not likely that real spending on R&D will increase or even keep pace with inflation. Industry is the largest user of R&D, using nearly all their own funds as well as 30% of Federal R&D funds. Industry typically sends only 1.5% of their R&D funds out-of-house, mostly to Universities. Universities have limited self-funding (endowments, state and local grants, non-profit funding) resources, but receive about 19% of Federal R&D funds. In total, Universities are currently spending nearly the same amount on R&D as are all Federal laboratories combined (all DOE, DOD, NIH, NASA, NIST, etc., labs). The DOE Weapons laboratories only spend 15% as much as universities spend on R&D.

GDP, industry figures, and personal savings are shown in Figure B-6. Industrial profits tumbled between 1979 and 1982, but have increased fairly steadily since that time. However, personal savings has remained relatively constant since 1975, with perhaps a slight downward trend, despite the increase in population and productivity over the same period. Thus, the personal savings rate has been decreasing in the US for many years.

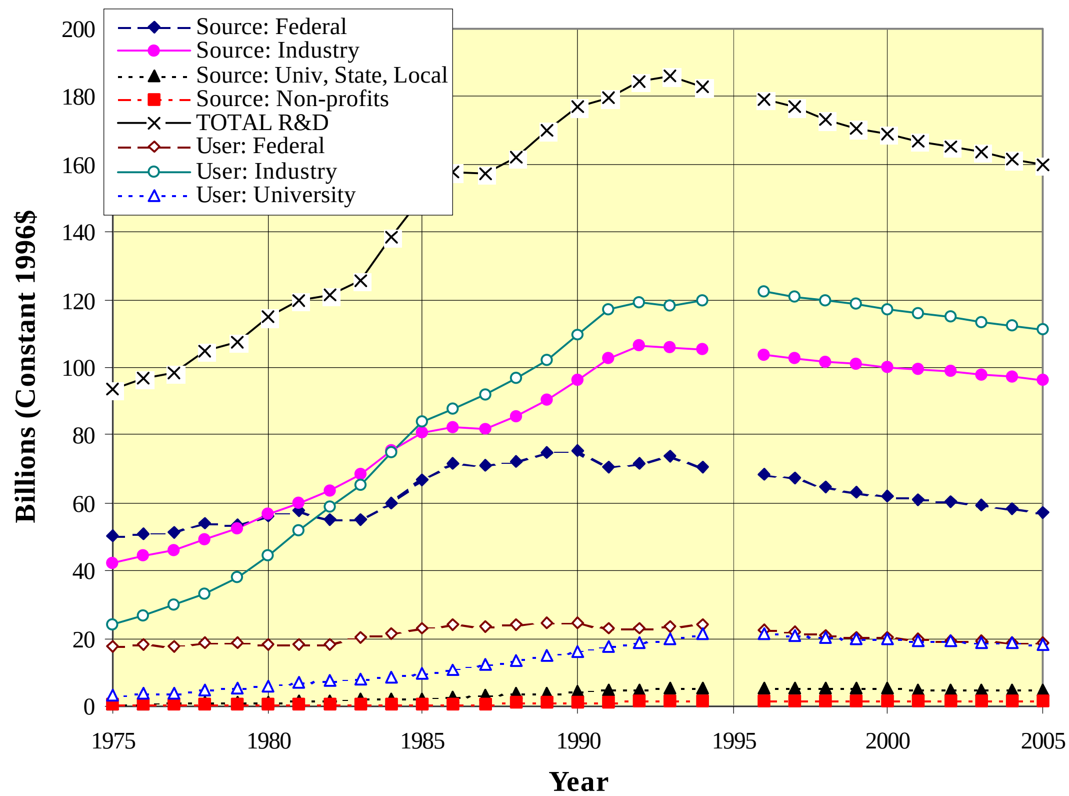


Figure B-5. Historical and Projected US R&D Sources and Spending.

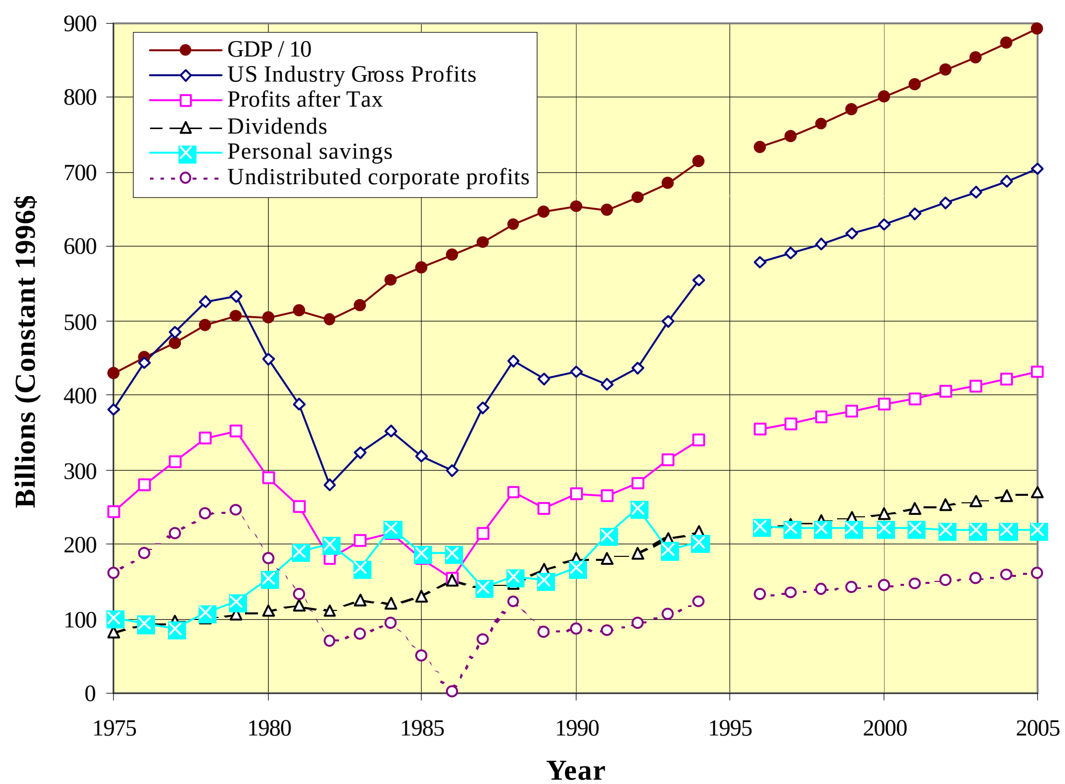


Figure B-6. Historical and Projected US Industry and Personal Saving Figures.

The initial money allocations in the game, as given in the 'Money' section of the handbook, have been determined in a way that allows all teams to have some power in the game, and to have money roughly equal to their relative influences in the R&D arena. Only R&D moneys have been initially allocated. Other moneys, such as US budget expenditures for Social Security, agency non-R&D budgets, etc., have not been allocated, since the purpose of this game is to focus on R&D. The allocation method for this game is given in Table B-2. The source of money shown in Table B-2 is from the corresponding entry in Table B-1.

Table B-2. Basis for Money Allocation in this Prosperity Game

Team	Fraction	Source of Money
US Ind. #1 (IT/Mfg.)	0.42%	US Companies R&D
US Ind. #2 (E/E)	0.14%	US Companies R&D
US Ind. #3 (LS/Mat.)	0.14%	US Companies R&D
US Ind. #4 (NS/CJ)	0.14%	US Companies R&D
Universities	0.75%	University R&D
Foreign Team	0.50%	Foreign Companies R&D in US

Following these initial allocations, subsequent allocations from team to team are projected to be as shown in the 'Money' section of the handbook.

B-3: Technology Innovation Legislation Highlights
Prepared by the Federal Laboratory Consortium (FLC) for Technology Transfer

Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480)

Focused on dissemination of information.

Required federal laboratories to take an active role in technical cooperation.

Established Offices of Research and Technology Application at major federal laboratories.

Established the Center for the Utilization of Federal Technology (in the National Technical Information Service).

Bayh-Dole Act of 1980 (Public Law 96-517)

Permitted universities, not for profits, and small businesses to obtain title to inventions developed with governmental support.

Allowed government-owned, government-operated (GOGO) laboratories to grant exclusive licenses to patents.

Small Business Innovation Development Act of 1982 (Public Law 97-219)

Required agencies to provide special funds for small business R&D connected to the agencies' missions.

Cooperative Research Act of 1984 (Public Law 98-462)

Eliminated treble damage aspect of antitrust concerns for companies wishing to pool research resources and engage in joint,precompetitive R&D.

Resulted in Consortia: Semiconductor Research Corporation (SRC) and Microelectronics and Computer Technology Corporation (MCC), among others.

Trademark Clarification Act of 1984 (Public Law 98-620)

Permitted decisions to be made at the laboratory level in government-owned, contractor-operated (GOCO) laboratories as to the awarding of licenses for patents.

Permitted contractors to receive patent royalties for use in R&D, awards, or for education.

Permitted private companies, regardless of size, to obtain exclusive licenses.

Permitted laboratories run by universities and non-profit institutions to retain title to inventions within limitations.

Japanese Technical Literature Act of 1986 (Public Law 99-382)

Improved the availability of Japanese science and engineering literature in the US

Federal Technology Transfer Act of 1986 (Public Law 99-502)

Made technology transfer a responsibility of all federal laboratory scientists and engineers.

Mandated that technology transfer responsibility be considered in laboratory employee performance evaluations.

Established principle of royalty sharing for federal inventors (15% minimum) and set up a reward system for other innovators.

Legislated a charter for Federal Laboratory Consortium for Technology Transfer and provided a funding mechanism for that organization to carry out its work.

Provided specific requirements, incentives and authorities for the federal laboratories.

Empowered each agency to give the director of GOGO laboratories authority to enter into cooperative R&D agreements and negotiate licensing agreements with streamlined headquarters review.

Allowed laboratories to make advance agreements with large and small companies on title and license to inventions resulting from Cooperative R&D Agreements (CRADAS) with government laboratories.

Allowed directors of GOGO laboratories to negotiate licensing agreements for inventions made at their laboratories.

Provided for exchanging GOGO laboratory personnel, services, and equipment with their research partners.

Made it possible to grant and waive rights to GOGO laboratory inventions and intellectual property.

Allowed current and former federal employees to participate in commercial development, to the extent there is no conflict of interest.

Malcolm Baldrige National Quality Improvement Act of 1987 (Public Law 100-107)

Established categories and criteria for the Malcolm Baldrige National Quality Award.

Executive Orders 12591 and 12618 (1987): Facilitating Access to Science and Technology

Promoted access to science and technology.

Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418)

Placed emphasis on the need for public/private cooperation on assuring full use of results of research.

Established centers for transferring manufacturing technology.

Established Industrial Extension Services within states and an information clearinghouse on successful state and local technology programs.

Changed the name of the National Bureau of Standards to the National Institute of Standards and Technology and broadened its technology transfer role.

Extended royalty payment requirements to non-government employees of federal laboratories.

Authorized Training Technology Transfer centers administered by the Department of Education.

National Institute of Standards and Technology Authorization Act for FY 1989 (Public Law 100-519)

Established a Technology Administration within the Department of Commerce.

Permitted contractual consideration for rights to intellectual property other than patents in CRADAS.

Included software development contributors eligible for awards.

Clarified the rights of guest worker inventors regarding royalties.

Water Resources Development Act of 1988 (Public Law 100-676)

Authorized Army Corps of Engineers laboratories and research centers to enter into cooperative research and development agreements.

Allowed the Corps to fund up to 50% of the cost of the cooperative project.

National Competitiveness Technology Transfer Act of 1989 (Public Law 101-189) (included as Section 3131 et seq. of DOD Authorization Act for FY 1990)

Granted GOCO federal laboratories opportunities to enter into CRADAs and other activities with universities and private industry, in essentially the same ways as highlighted under the Federal Technology Transfer Act of 1986.

Allowed information and innovations brought into, and created through, CRADAs to be protected from disclosure.

Provided a technology transfer mission for the nuclear weapons laboratories.

Defense Authorization Act for FY 1991 (Public Law 101-510)

Established model programs for national defense laboratories to demonstrate successful relationships between federal government, state and local governments, and small business.

Provided for a federal laboratory to enter into a contract or memorandum of understanding with a partnership intermediary to perform services related to cooperative or joint activities with small business.

Provided for development and implementation of a National Defense Manufacturing Technology Plan.

Intermodal Surface Transportation Efficiency Act of 1991 (Public Law 102-240)

Authorized the Department of Transportation to provide not more than 50% of the cost of CRADAs for highway research and development.

Encouraged innovative solutions to highway problems and stimulated the marketing of new technologies on a cost shared basis of more than 50% if there is substantial public interest or benefit.

American Technology Preeminence Act of 1991 (Public Law 102-245)

Extended FLC mandate, removed FLC responsibility for conducting a grant program, and required the inclusion of the results of an independent annual audit in the FLC Annual Report to Congress and the President.

Included intellectual property as potential contributions under CRADAs.

Required the Secretary of Commerce to report on the advisability of authorizing a new form of CRADA that permits federal contributions of funds.

Allowed laboratory directors to give excess equipment to educational institutions and nonprofit organizations as a gift.

Small Business Technology Transfer Act of 1992 (Public Law 102-564)

Established a three-year pilot program, the Small Business Technology Transfer (STTR) program, at DOD, DOE, HHS, NASA, and NSF.

Directed the Small Business Administration (SBA) to oversee and coordinate the implementation of the STTR program.

Designed the STTR similar to the Small Business Innovation Research (SBIR) program.

Required each of the five agencies to fund cooperative R&D projects involving a small company and a researcher at a university, federally-funded research and development center, or nonprofit research institution.

National Department of Defense Authorization Act for 1993 (Public Law 102-25)

Facilitated and encouraged technology transfer to small businesses.

National Defense Authorization Act for FY 1993 (Public Law 102-484)

Extended the streamlining of small business technology transfer procedures for non-federal laboratory contractors.

Directed DOE to issue guidelines to facilitate technology transfer to small businesses.

Extended the potential for CRADAs to some DOD-funded Federally Funded Research and Development Centers (FFRDCs) not owned by the government.

National Department of Defense Authorization Act for 1994 (Public Law 103-160)

Broadened the definition of a laboratory to include weapons production facilities of the DOE.

National Technology Transfer and Advancement Act (H.R. 2196, 1995) Signed March 7, 1996

Simplifies negotiations regarding intellectual property rights arising from CRADAs. Federal labs will ensure to their private-sector CRADA partners “the option to choose an exclusive license for a pre-negotiated field of use for any … invention made in whole or in part by a laboratory employee under the agreement.” The lab has the right to “reasonable compensation when appropriate.”

APPENDIX C: PROSPERITY GAMES

PROSPERITY GAMES

Prosperity Games simulate and explore complex issues

A Prosperity Game is a new type of forum for simulating and exploring complex issues in a variety of areas including economics, politics, sociology, environment, education, research, health care, etc. The issues can be examined from a variety of perspectives ranging from a global, macroeconomic and geopolitical viewpoint down to the details of customer/supplier/market interactions in specific industries.

Prosperity Games are an outgrowth of move/countermove and seminar war games. They are executive-level interactive simulations that encourage creative problem solving and decision-making, and explore the possible consequences of those decisions in a variety of economic, political and social arenas. The simulations are high-level exercises of discretion, judgment, planning and negotiating skills, not computer games. They explore the challenges and opportunities faced by businesses, government, laboratories, universities and the public.

Games should involve look-ahead strategies

Thirteen previous Prosperity Games have explored environmental issues, economic competitiveness in electronics manufacturing and information technology, university business education, the business case for diversity, the DOE labs, and biomedical technologies (see Table C-1).

GAME THEORY

In mathematics, game theory is the study of strategic aspects of situations of conflict and cooperation. "Game Theory approaches conflicts by asking a question as old as games themselves: How do people make 'optimal' choices when these are contingent on what other people do?"[8] Game theory originated with the mathematician John von Neumann as early as 1928. The collaboration of von Neumann on theory and Oskar Morgenstern on applications to economic questions led to the seminal book *The Theory of Games and Economic Behavior* that first appeared in 1944, and was later revised in 1947 and 1953. Game theory is an approach to developing the best strategies in areas such as economics and war to beat a competitor or enemy. [Of course, one possible strategy is to convert an enemy into an ally, or a competitor into a partner!]

A game is defined by a set of rules that specify the players, their desired goals, allowed interactions, and a method of assessing outcomes. There can be one or more goals with different levels of importance. The players adopt strategies, and the interactions of the "moves" based on those strategies lead to outcomes which may or may not be consistent with the players' goals. Complex games involve look-ahead strategies that address the different possible moves that an opponent could make. It is important to try to understand an opponent's goals in order to maximize the probability of a favorable outcome. Games can be sequential, with player interaction allowed between moves.

[8]From Steven J.Brams, "Theory of Moves," *American Scientist*, **81**, 562-570, November-December 1993.

Table C-1: Thirteen Prosperity Games have been conducted.

Game	Sponsors
1. Sandia prototype	Sandia (4700)
2. Electronics Industries Association Board of Governors, Palm Springs, California, January 20-21, 1994	EIA
3. American Electronics Association, Washington, DC, March 8-9, 1994,	AEA
4. Advanced Manufacturing Day, Albuquerque, NM, May 17, 1994	Sandia (4700)
5. National Electronics Manufacturing Initiative Prototype, Albuquerque, NM, June 9-10, 1994	Sandia (4700)
6. National Electronics Manufacturing Initiative Game, Mt.Weatherall, Virginia, Sep. 7-9, 1994	NEMI, DARPA, EIA, AEA, Sandia
7. Environmental Game Prototype, Albuquerque, NM, February 6, 1995	Sandia, Silicon Valley Environmental Partnership, LLNL, et al.
8. Environmental Prosperity Game, San Ramon, CA, March 29-31, 1995	Silicon Valley Environmental Partnership, Alameda Economic Development Advisory Board, Bay Area Economic Forum, Sandia
9. University Game, Anderson School of Management, University of New Mexico, April 4 - May 2, 1995	Anderson School of Management (UNM), Sandia
10. Diversity and DOE/Laboratory Game, Albuquerque, NM, May 24-25, 1995	Sandia (4000)
11. Prototype Biomedical Technology Game, Albuquerque, NM, Sep. 22, 1995	Sandia (9400)
12. Biomedical Technology Game, Albuquerque, NM, November 1-3, 1995	Sandia (9400)
13. Prototype Future of the DOE Labs, Albuquerque, NM, March 21-22, 1996	Sandia, LANL, LLNL, ORNL, Lockheed-Martin, University of California

APPENDIX D: GAME METRICS

Six metrics will be tracked and updated during the game to simulate the impact of game play on life in the United States. The primary purpose of these metrics is to provide an additional tie to the real world when the results of the game are analyzed. These metrics are: growth in GDP/capita (%), growth in corporate profits (%), federal deficit/GDP (%), trade balance/GDP (%), quality of life, and defense preparedness. Current and forecasted data have been used to calculate a baseline projection for each of these metrics as shown in Figure D-1. Quality of life is based on four factors: security (primarily economic), personal safety, health, and environment, and is intended to show how the general population of the US feels about trends in these four areas. In Figure D-1, the four metrics designated with (%) are measured by the scale on the left-hand axis, while quality of life and defense preparedness correspond to the scale on the right-hand axis.

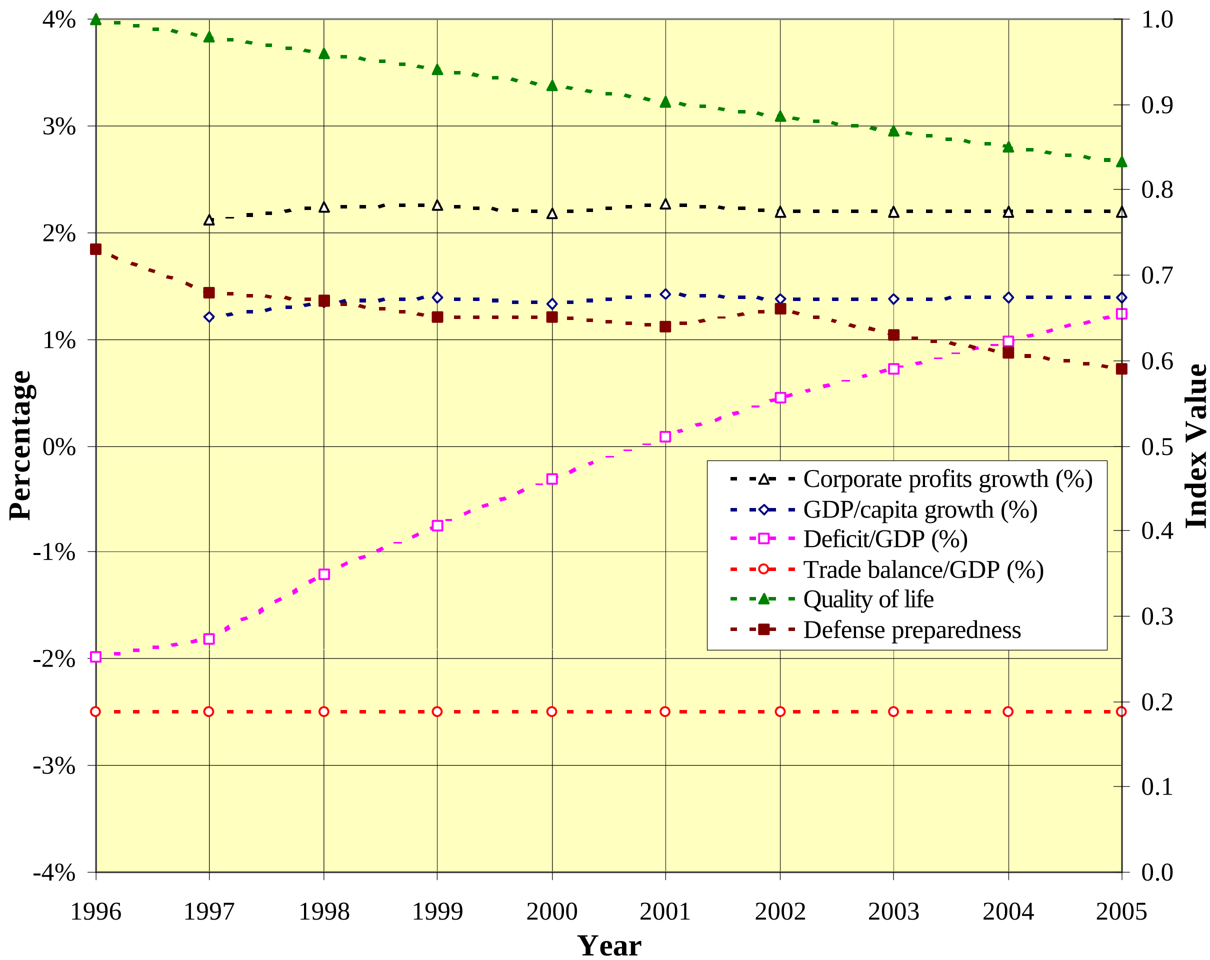


Figure D-1. Baseline projections for Prosperity Game metrics.

Most of the metrics are not directly measurable in the game context. Thus, correlations have been made between these metrics and actions that are directly measurable in the game, and that depend on the actions of the players. These factors may include the nature of agreements and contracts, the quality and robustness of agreements, total investment spending, spending by sector, leveraging between certain groups of teams, funding allocation changes, and the information processing level exhibited by agreements.

APPENDIX E: GLOSSARY AND ACRONYMS

ADaPT	Advanced Design and Production Technologies
AMPEC	AdvancedMaterials and Processes for Economic Competitiveness
ANL	Argonne National Laboratory
ASCI	Accelerated Strategic Computing Initiative
ASKC	Allied Signal Kansas City
BNL	Brookhaven National Laboratory
CPI	Consumer Price Index
CRADA	Cooperative Research and Development Agreement
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FDA	US Food and Drug Administration
FFRDC	FederallyFunded Research and Development Center
FLC	Federal Laboratory Consortium for Technology Transfer, organized in 1974 and formally chartered by the Federal Technology Transfer Act of 1986 to promote and strengthen technology transfer. Includes more than 600 federal laboratories and their parent departments and agencies.
FLOPS	Floating point operations per second; a measure of computing speed
GAO	Government Accounting Office
GDP	Gross Domestic Product
GOCO	Government Owned Contractor Operated
GOGO	GovernmentOwned Government Operated
HHS	Health and Human Services
HPC	High Performance Computing
Industrial Ecology:	The application of ecological principles to industrial processes. Its objective is to continually increase the resource-efficiency of those processes – in other words, to increase their knowledge-content.
INEL	Idaho National Engineering Laboratory
ITER	International Thermonuclear Experimental Reactor: An international (Europe, Russia, Japan, US) program to build a fusion reactor; The Engineering Design Activities (EDA) is a 6-year program that began in July 1992. ITER costs have been estimated at $8B, but some think it will cost twice that.
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
MCC	Microelectronics and Computer Corporation
MEMS	Microelectromechanical systems that merge information processing and communication with sensing and actuation. The worldwide market for MEMS devices for three key defense categories - miniaturized inertial measurements, distributed sensing, and information technology - is expected to increase to $14B per year by 2000.
micro-	one millionth-
MIT	Massachusetts Institute of Technology
MITI	Ministry of International Trade and Industry (Japan)
nano-	one billionth-

NASA	National Aeronautics and Space Administration
National Security:	Protection of American citizens from threats to their safety, security, prosperity, and well-being.
NIF	National Ignition Facility; a massive laser fusion laboratory that would determine the safety and reliability of the US nuclear weapons stockpile in the absence of testing.
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
OTA	Office of Technology Assessment
PNL	Pacific Northwest Laboratory
R&D	Research and Development
ROI	Return on Investment
SBA	Small Business Administration
SBIR	Small Business Innovative Resource
SNL	Sandia National Laboratories
SRC	Semiconductor Research Corporation
S&T	Science and Technology
STTR	Small Business Technology Transfer
STS	Science, Technology and Society
TEAM	Technologies Enabling Agile Manufacturing
Technology Roadmap:	A strategic plan that collaboratively identifies product and process performance targets and obstacles, technology alternatives and milestones, and a common technology path for R&D activities."
Tera	Trillion; 10^{12}
TFLOPS	Trillion floating point operations per second; a measure of computing speed. Also, a $45.5M project under ASCI, whose goal is to produce a massively parallel computer capable of 1.8 TFLOPS.

GAME SCHEDULE

Monday, May 6, 1996

4:30 pm	Participant registration and badging; collect materials.
5:00 pm	Players gather in Conference Center; get acquainted with team members. “Hello” process; go to assigned tables.
5:30 pm	Welcome: Deborah Wince-Smith, Donald M. Kerr, Milton Klein
6:00 pm	Prosperity Game briefing/overview with questions and answers; polling (Marshall Berman -- Game Director)
7:00 pm	Dinner with your team members.
8:00 pm	Formal meeting adjourned. Private team meetings and discussions may begin.

Tuesday, May 7, 1996

7:30 am	Breakfast Buffet
	SESSION 1 - May, 1996:
8:00 am	Facilitators lead teams in initial assignments: **All teams**: Set ground rules for deliberation, decision-making, etc. Review the team challenges defined in this Handbook. Modify and complete the challenges for your team. Define the different roles appropriate to your team and which players will represent each role. Develop game, team and personal objectives and strategies to meet your challenges. Begin to implement those strategies. Prepare Toolkit Investments. Make appointments with other teams to begin preliminary discussions.
10:30 am	Break
	SESSION 2 - January 1, 1997:
10:45 am	Introduction to Session 2. Plan Toolkit investments; partner with other teams.
11:50 am	End of Session 2. ***Complete all Toolkit investments and submit only your own team’s options to Control team. No further Toolkit investments are allowed after 11:50 am.***
11:55 am	Radio news broadcast.
12:00	Lunch Luncheon Speaker, C. Paul Robinson, Sandia National Laboratories
	SESSION 3 - January 1, 1998:
1:00 pm	Successful Toolkit investments are announced and implemented. Introduction to Session 3.
1:30 pm	New money distributed. Continue deliberations and negotiations.
2:55 pm	Radio news broadcast.
3:00 pm	Break

SESSION 4 - January 1, 2000:

3:30 pm — ***Staff updates the world.*** Successful technologies and policies that have been negotiated among the teams are announced and implemented into the game.

Teams assess status and progress; realign strategies as needed.

4:00 pm — New money distributed. Continue deliberations and negotiations.

5:30 pm — Teams select Ambassadors to National R&D Summit Meeting. Submit names to Control Team. Provide one topic for the Summit Meeting. End of day's activities

Wednesday, May 8, 1996

7:30 am — Continental Breakfast

8:00 am — Announcements. Introduction to Summit Meeting. Selection of topics and discussion.

8:30 am — **NATIONAL R&D SUMMIT MEETING**

10:00 am — Radio news broadcast.

10:05 am — Break

SESSION 5 - January 1, 2002:

10:30 am — ***Staff updates the world.*** Successful technologies and policies that have been negotiated among the teams are announced and implemented into the game.

Teams assess status and progress; realign strategies as needed.

10:45 am — New money distributed. Continue deliberations and negotiations.

12:00 — Active play ceases.
Radio news broadcast.

12:05 pm — Lunch
Luncheon Speaker

SESSION 6 - January 1, 2004:

1:00 pm — Teams digest game results, document best ideas, plan for follow-on activities, get volunteers to champion follow-ons.

2:00 pm — Final radio news broadcast.

2:05 pm — Play ceases. Teams select spokesperson; prepare final presentations. Vote on self-assessments.

3:15 pm — Team debriefings and self-assessments - no more than 5 minutes each; group assessment by Innovator.

- Challenges
- Strategies
- Successes
- Failures

4:30 pm — Wrap up; final polling; fill out evaluation forms.

5:00 pm — Game adjourned.